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The *Journal of Public Transportation* mourns the loss of University of Iowa Professor Emeritus David Forkenbrock, who passed away on January 11, 2008. Professor Forkenbrock and his contributions as a distinguished colleague in the transportation research community will be missed and long remembered.

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CONTENTS

Impacts of Transit Benefits Programs on Transit Agency Ridership, Revenues, and Costs

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Abstract

The federal tax code allows employers to provide tax-free transit benefits to employees. Although transit benefits programs are commonly promoted as having advantages for transit agencies, such as increasing transit ridership and transit agency revenues, their effects and effectiveness are not well understood and need to be better assessed. This research is designed to help transit agencies, policy-makers, and organizations that promote transit benefits better understand what effects they might expect from a transit benefits program and how to quantify these effects. Overall, the research found that transit benefits programs can be effective for transit agencies attempting to meet various goals, in terms of increasing ridership and revenues, and decreasing costs. However, it is critical to set realistic expectations and conduct valid evaluations to assess these effects.

Introduction

U.S. tax law allows employers to offer employees tax-free transit benefits (U.S. Department of the Treasury 2004). Regardless of how the benefits are offered (employer-paid, employee-paid, or a combination of the two), both the employer and the employee enjoy tax advantages since neither pays federal payroll or income taxes on the benefit. Although the cost savings from the benefits are relatively straightforward, their impacts on transit ridership are not as well understood, and little rigorous research has been conducted on the topic at a national scale. While it makes intuitive sense that transit benefits programs should increase transit use, it is possible that these programs primarily support existing transit riders.

To induce employers to offer transit benefits, many transit agencies have established programs that allow employers to purchase various pass types and vouchers at a discount, in bulk, or using other types of incentives. These programs make it easy for employers to offer transit benefits, as well as provide the transit or other sponsoring agency an opportunity to "brand" their program and increase their name recognition. In addition, tax law allows employers to purchase fare media on a cash reimbursement basis if no pass or voucher is available in the region, giving the agency another incentive to create a transit benefits program.

This research focuses on how transit benefits programs affect transit agencies in terms of ridership, revenues, and costs. The following questions provide a rough outline of the topics covered in the article:

- How much systemwide ridership and revenues come from transit benefits programs? The share of overall ridership and revenues that come from employer programs affects the extent to which these programs can help retain and attract riders and yield cost savings to the transit agency.
- Do transit benefits programs increase transit ridership and revenues? Research on the impacts of transit benefits programs on employee travel behavior suggests that such efforts can increase transit ridership. This article explores the extent to which transit ridership and revenues increase, and how program design affects revenues per rider.
- How much do transit benefits programs cost to administer? These costs include staff time for employer outreach as well as marketing and other fees.
- Are there differences in revenue, ridership, or cost characteristics between different program types? If different types of programs (e.g., universal passes, monthly passes) generate different levels of revenues per rider and have different costs, it is useful for transit agencies to understand these effects so that they can offer the program options that best meet their goals.

Data Sources and Approach

The results summarized in this section are drawn from interviews that the research team conducted in 2003 with representatives from the following seven transit agencies. These agencies were selected to participate because they provide a range of mode options and program types, cover various geographic areas,[1] and have differing ridership levels:

- Washington Metropolitan Area Transit Authority (WMATA), Washington, D.C.
- Metropolitan Atlanta Rapid Transit Authority (MARTA), Atlanta, Georgia
- King County Metro, Seattle, Washington
- Regional Transportation District (RTD), Denver, Colorado
- Metro Transit, Minneapolis/St. Paul, Minnesota
- Santa Clara Valley Transportation Authority (VTA), San Jose, California
- Valley Metro, Phoenix, Arizona

As the focus of the research was ridership, revenues, and costs to transit agencies, and the differences between different types of pass programs, we studied only agencies that operate their own program pass or voucher programs. A subset of voucher programs are operated by private third-party providers, sometimes as the sole program, sometimes in conjunction with public agency programs. However, the research team chose not to include regions where these were the only programs, as they represent only voucher and not pass programs.

The research team conducted the interviews using an interview guide, asking follow-up or clarifying questions when necessary. In some cases, the persons interviewed sent additional information following the interview. Table 1 provides background information on the seven transit agencies. As part of the project, the research team also collected ridership surveys and surveys pertaining to commuter benefits where available.

Types of Transit Benefits Programs

Of the seven transit agencies interviewed, four had multiple programs. Types of employer programs offered included monthly passes, stored value cards, universal passes, and vouchers (which can be traded in for transit fare media or used on vanpools). Generally these situations have evolved in response to employer demands and available technology. As Table 1 shows, three of the seven agencies have only one employer program, and King County Metro has seven.

Table 1. Summary Characteristics of Transit Agencies and their Program Types (2003)

Transit Agency Name	*Location*	*Modes*	*Service Area Population*	*Average Weekday Ridership*	*Annual Fare Revenues*	*Program Name*	*Program Type*	*Year Began*
WMATA	Washington, DC	Heavy rail, bus	1,300,000	1,350,000	$384,000,000	Metrochek	Stored value card/Voucher	1993
						Smart Benefits	Stored value card/Electronic voucher	2000
MARTA	Atlanta, GA	Heavy rail, bus	1,300,000	460,000	$93,000,000	MARTA Partnership Program	Monthly pass with volume discount	1992
King County Metro	Seattle, WA	Bus only	1,800,000	330,000	$76,000,000	Flex Pass	Universal pass	1993
						UPass	Universal pass	1990
						GoPass	Universal pass	1997
						Consignment Retail Pass	Monthly pass	1977
						Phone/Mail Program	Monthly pass	N/A
						Commuter Bonus Voucher	Voucher	1995
						Bonus Plus Vouchers	Rewards program	1996
RTD	Denver, CO	Light rail, bus	2,400,000	270,000	$51,000,000	Eco Pass	Universal pass	1991
Metro Transit	Minneapolis/ St. Paul, MN	Bus only	1,800,000	220,000	$60,000,000	Metro Pass	Modified universal pass	1998
						TransitWorks!	Discounted pass	N/A
VTA	San Jose, CA	Light rail, bus	1,700,000	150,000	$33,000,000	Eco Pass	Universal pass	N/A
Valley Metro	Phoenix, AZ	Bus only	2,000,000	140,000	$27,000,000	Bus Card Plus	"Credit card" for bus	1991
						Private Outlet	Monthly pass	N/A

Note: All figures for service area population, average weekday ridership, and annual farebox revenues are from the National Transit Database, 2003. Population rounded to nearest 100,000; ridership rounded to nearest 10,000; revenues rounded to nearest $1 million. The service area is reported by the transit agency based on their service provision; this may be substantially less than the urbanized area.

Ridership Impacts

Among the agencies interviewed, employer programs contributed between 5 and 25 percent of total transit riders, and agencies with trend data available have shown increases in employee participation over time. However, it is difficult to determine if the increases in employee participation have led to increased ridership systemwide; in two cases the answers is a qualified yes, while in two others the effects are unclear.

Employee Participation

Employees participating in transit benefits programs make up a substantial portion of total transit ridership for many transit agencies. The agencies interviewed estimated that the percentage of all riders using employer transit benefits programs was between 5 and 25 percent. The highest percentages of transit riders who participate in employer-sponsored transit benefits programs were at WMATA, Valley Metro, and King County Metro. WMATA attracts a large number of federal employees who receive full employer-paid benefits. Valley Metro is the smallest of the seven agencies in terms of total systemwide ridership, but has the largest number of staff working in employer outreach (including rideshare programs), so the program's success may stem in part from this intensive effort.

Table 2 provides ridership figures for each program and the percent of total system riders using transit benefits.

Employee Participation Trends

Employee participation in transit benefits programs has been increasing for nearly all of the agencies that provided historical participation trends. Even where *employer* participation has declined or remained relatively unchanged, *employee* participation has consistently increased. Five agencies had trend information on the number of employees participating in transit benefits programs, which is graphed in Figure 1.[2] Three of these are universal pass programs, which track the number of employees at participating employers. While generally not all universal pass recipients ride transit, the figures assume that all of King County's UPass program employee participants ride transit, since students, faculty, and staff are allowed to opt out of the program.

Table 2. Employee Participation in Transit Benefits Programs (as of 2003)

Transit Agency	*Program Name*	*Number of Participating Employees*	*% All Riders Using Employer Passes*[a]
WMATA	Metrochek	189,067	N/A
	Smart Benefits	18,933	N/A
	Total	208,000	25%
MARTA	Partnership Program	30,700	<10%
King County Metro	Flex Pass	38,000 to 40,000 (est.)	6% to 8%
	UPass and GoPass	48,600[b]	>10%
	Retail programs	10,000 to 14,000 (est.)	3%[c]
	Voucher programs	N/A	N/A
	Total	95,000 to 103,000	20% to 22%
RTD	Eco Pass	52,700 (est.)[d]	12 to 21%[e]
Metro Transit	Metropass	15,000	7%
	TransitWorks!	12,000	5% (est.)
	Total	27,000	12% (est.)
VTA	Eco Pass	42,800 (est.)[f]	5%
Valley Metro	Bus Card Plus	12,189	11%
	Private Outlet	12,000 (est.)	11%
	Total	Over 24,000	22%

a. Estimated by transit agency staff, unless otherwise noted.

b. UPass ridership is lower during summer quarter; approximately 26,000.

c. Based on King County Metro staff estimates for other programs.

d. Estimated ridership based on survey figures showing that 67 percent of eligible employees participate (ICF et al. 2005, Appendix C).

e. 14 percent of bus riders, 12 percent of light rail riders, and 21 percent of skyRide riders. No numbers were given, so an overall total could not be estimated.

f. Estimated ridership based on survey figures showing that 36.4 percent of eligible employees participate (ICF et al. 2005, Appendix C).

N/A = not available.

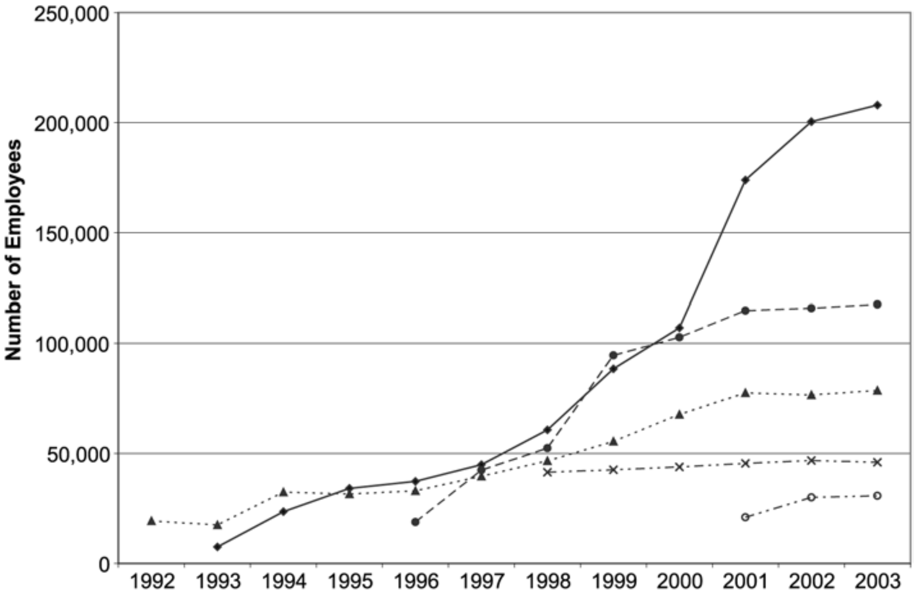

Figure 1. Trends in Employee Participation at Five Transit Benefits Programs

Most striking is the large jump in participation in WMATA's transit benefits program from 2000 to 2001. Two factors contributing to this increase were the increase in the tax-free limit from $65 to $100 and implementation of an Executive Order that requires federal government agencies to fully pay for transit benefits up to the tax-free limit for all interested executive branch employees in the Washington, D.C. region. VTA, MARTA, and RTD have shown much steadier increases in employee participation over time. VTA and MARTA reported being affected by economic downturns, and all three had fare increases (or in the case of MARTA, a reduction in the employer discount that made employers' costs higher). The strong employee participation figures seem to indicate that the programs are fairly resilient in the face of financial obstacles for employers. Participation in King County's UPass has been steady, but the program only serves the University of Washington, and so it may have reached its saturation point among potential recipients.

Contributions of Transit Benefit Riders to Overall Ridership Growth

It is difficult to develop quantitative estimates of the extent to which the transit benefits programs have affected overall transit ridership at agencies over time because it is impossible to state what ridership trends would have been if such programs were not in place. However, based on data on total transit system ridership from the National Transit Database (NTD) and available survey data on the share of transit benefits recipients who are new to transit or who increased their transit use, the research team developed estimates of the contribution of the transit benefits program to total system ridership. Estimates for these agencies suggest that the transit benefits programs may have been responsible for a substantial—perhaps 30 or 40 percent—portion of ridership growth between 1997 and 2001 (the most recent year for NTD data on ridership at the time this research was conducted) at two agencies. At the other two agencies, the results were mixed. Limitations in survey data (i.e., small sample sizes, low employee response rates, surveys that were conducted many years in the past), however, create a high degree of uncertainty in these estimates.

For WMATA, a noticeable increase in overall transit ridership—118 percent—occurred in 2001, which corresponds with the steep increase in the number of employees participating in the transit benefits program. From 1997 to 2001, the number of weekday rides on WMATA services increased by nearly 187,000, while the number of transit benefits participants increased by 127,100.[3] Assuming that approximately one-quarter of transit benefits recipients in the Washington, D.C. area are new riders (General Accounting Office 1993), and that the average recipient might take two transit trips per day, this suggests that perhaps *up to* about 60,000 new transit riders over this period were due to the transit benefits program. If this were the case, the transit benefits program may have accounted for approximately 34 percent of the ridership growth. However, the survey data may not reflect the actual ridership patterns of transit benefits recipients during the 1997 to 2001 period. A more recent State of the Commute survey (LDA Consulting et al. 2002) covering the Washington, D.C. region found that approximately 48 percent of people who use Metrochek say that they "were influenced by" it, which could mean a number of things, from riding transit more often to continuing to stay on transit (not switching to driving alone); this survey also includes non-WMATA riders (e.g., riders on suburban bus services). It *may* indicate that with more than $100 per month available now, an even higher portion of Metrochek users are new riders or more frequent riders.

At RTD, the number of employees participating in the Eco Pass program increased from 1997 to 2001 by approximately 25,400, while overall ridership during that period increased by 29,600 rides per day. An ongoing RTD survey of employees at employers participating in the Eco Pass program (ICF et al. 2005, Appendix C) suggests that 24 percent of all recipients are new transit riders. As a result, the employer program may have accounted for about 6,000 new riders per day, or assuming two transit trips per day, *up to* nearly 42 percent of the overall growth.

The gains at VTA *may* have contributed to an increase in ridership. Between 1997 and 2001, the number of weekday rides on VTA services increased by approximately 13,000 trips, while the number of Eco Pass participants increased by approximately 26,400.[4] A VTA survey of employees at six participating employers (ICF et al. 2005, Appendix C) found that about 61 percent of Eco Pass recipients are new transit riders. As a result, the employer program *may* have accounted for approximately 16,000 new riders. However, several factors lend some uncertainty to this estimate: the small sample size of the 1997 survey (only six employers), the expansion of both light rail and bus service from 1997 to 2001, and the strong employment rate during that period. So while the Eco Pass program may be one of several factors responsible for the overall growth in VTA ridership, it is difficult to say which factors were most important.

For MARTA, program participation rose from 21,000 to 30,700 between 2001 and 2003, while total agency ridership declined during the same period, from 530,450 to 461,000 daily weekday riders. Survey data collected in 2003 (ICF et al. 2005, Appendix C) showed that 48 percent of program participants were new transit riders. Given that the number of participants increased by 9,700, this implies approximately 4,600 new riders in two years. However, clearly this increase did not overcome a larger decline in ridership.

Revenue Impacts

Total revenues associated with employer sales can be a significant portion of total transit agency revenues. As shown in Table 3, the percentage of total agency revenues associated with employer sales for the seven agencies ranges from 5 to about 40 percent of total agency revenues. Metro Transit and King County Metro report the highest shares of revenues from employer sales, followed by WMATA. These are significant shares of total revenues, which may have implications in terms of the efficiency of distributing fare media and reducing the costs of individual transactions. Overall, revenues tend to be related to the size of the transit agency and costs of fare media.

Table 3. Estimated Revenues Associated with Transit Benefits Programs (as of 2003)

Transit Agency	Program Name	Annual Revenue in $million	% Revenue from Program	Agency's Perception of Impact on Revenues
WMATA	Metrochek	$177.0	30%	Increase
	Smart Benefits	$13.8		
	Total	$190.8	30%	
MARTA	Partnership Program	$20.0	11% (est)[b]	Increase
King County Metro	Flex Pass	$6 to $7	8 to 10%	Increase
	UPass and GoPass	$10.7	14%	
	Retail programs	$9 to $12	13 to 17%	
	Voucher programs	$6.7[a]	N/A	
	Total	$25.7 to $29.7[a]	35 to 41%	
RTD	Eco Pass	$8.1	17%	Unclear
Metro Transit	Metropass	$15.1	25%	Neutral
	TransitWorks!	$10.0	17% (est)	
	Total	$25.1	42% (est)	
VTA	Eco Pass	$1.7	5%	Neutral
Valley Metro[b]	Bus Card Plus	$3.6	N/A	Increase

Notes:

a. Commuter Bonus Voucher not included in total because they may be spent on other fare media, which could result in double counting.

b. Only the Bus Card Plus program is included here because information was not available for the Private Outlet program.

N/A = not available.

Four of the seven transit agencies reported that they believe their transit benefits programs increase revenues, while three of the agencies felt that the programs have a neutral or unclear impact. The agencies reporting neutral or unclear impacts are all agencies with universal passes, where the cost of the passes are discounted to employers and often are designed so that the employer does not pay more than it would to cover existing transit riders. In contrast, to the extent that a monthly pass program increases the number of employees using transit, it should result in increased revenues. For stored value card programs, an increase in the number of employees using transit or an increase in the frequency of transit use by existing riders should result in increase revenues.

For all of the programs with data on revenues (either provided by the transit agency or developed by the research team based on data from the National Transit Database or the transit agencies), the estimated share of transit agency revenues from the transit benefits program equaled or exceeded the share of system ridership from the program. These figures suggest that employer programs are not losing potential revenue.

Cost Impacts

Cost implications of transit benefits programs for transit agencies are not well understood due to lack of data. Transit agencies were able to provide only general data on the costs of running their programs. Staff time tends to be the largest component of these costs, and staff needs vary from one full-time equivalent (FTE) to almost seven, largely depending on program type. Transit benefits programs may generate some cost savings for the transit agencies but these could not be quantified due to the lack of data collected by the transit agencies.

The costs associated with operating and marketing a transit benefits program for employers were estimated based on the transit agencies' projections of staff time and other resources, such as marketing and fulfillment budgets. Table 4 summarizes these figures for the seven transit agencies. It also estimates costs as a portion of revenues from the program, and annual costs per rider, which ideally could be used to assess how efficient these programs are in comparison to other marketing efforts. Given limited data, however, such comparisons could not be made. Each of the major components of agency costs associated with transit benefits program are described below.

Staff Time

Staff time differed greatly among programs, from 1 FTE at MARTA to 5.2 to 6.6 at King County Metro (staff requirements change throughout the year). The number of staff is not correlated with ridership or revenues; rather, the number of staff required to administer a single program appears to be tied most directly to program type. With one exception (the King County UPass program), regardless of ridership or revenues, universal pass programs seem to require a minimum of 2.5 staff. The RTD Eco Pass program has 3.6 FTEs, but handles far more employers (more than 1,000, while the other universal pass programs enroll several hundred employers). Presumably this is because the complexity of universal pass programs (compared with monthly pass programs) requires more time with employers, surveys, and more frequent repricing. Less complex programs seem to require fewer staff. With the exception of Valley Metro, monthly pass programs used 1 to 2 FTEs.

Marketing Budgets

Marketing budgets also covered a wide range, from no separate budget to $300,000; some agencies did not have a marketing budget for transit benefits broken out separately from general transit marketing. The power of a transit agency's marketing budget can be stretched depending on other partners in the region. All

Table 4. Estimated Costs Associated with Transit Benefits Programs (as of 2003)

Transit Agency	*Program Name*	*Staff Time (FTE)*	*Marketing Budget*	*Other Costs*	*Total Estimated Costs*[a]	*Costs as % of Revenue*	*Annual Cost per Rider*
WMATA	Metrochek	4	$300,000	Not specified			
	Smart Benefits						
	Total	4	$300,000		$510,000	0.3%	$3
MARTA	Partnership Program	1	$0[b]	Not specified	$83,000	0.4%	$3
King County Metro	Flex Pass	2 to 3	Under $5,000	Not specified	$142,000	2.4%	$4
	UPass and GoPass	.2	$0		$14,000	0.1%	<$1
	Retail programs	2	$0		$115,000	1.1%	$10
	Voucher programs	1 to 1.4	$0		$81,000	1.4%	N/A
	Total	5.2 to 6.6	Under $5,000		$364,000	1.2 to 1.3%	$3
RTD	Eco Pass	3.6	$25,000	$18,500 (fulfillment)	$293,500	2.4%	$6
Metro Transit	Metropass	2.25	$87,500	$225,000	$312,500	2.1%	$21
	TransitWorks!	2	$0	$150,000	$150,000	1.5%	$13
	Total	4.25	$87,500	$375,000 (salaries)	$462,500		$17
VTA	Eco Pass	2.5	$26,550	$240,000 (salaries)	$266,550	11.1%	$6
Valley Metro[c]	Bus Card Plus	4	$0[d]	Not specified	$360,000	10.0%	$30

a. Includes staff time, marketing, and fulfillment. Staff time was calculated based on figures of $47,250 per staff FTE and $67,250 per managerial FTE, which include salary and benefits and rounded up to the nearest thousand dollars. In all cases, we assumed one manager per separate program and the remainder staff.

b. Marketing for the Partnership Program is part of overall transit marketing budget; exact figures not available.

c. Only the Bus Card Plus program is included here because information was not available for the Private Outlet program.

d. General marketing budget of $650,000, but not for these programs.

N/A = not available.

seven regions had other public or private sector entities helping market transit benefits to employers. Budget differences may be explained by targeted versus general marketing strategies, effectiveness of specific campaigns, and general awareness of transit benefits within a region. It may also be that agencies defined their budgets differently.

Fulfillment

When asked about a fulfillment budget, most transit agencies reported that they considered fulfillment part of the salaries paid to employees and did not have separate figures available. Only three agencies had separate budget items for fulfillment, ranging from $18,500 to $375,000. Of those three, two included salaries in their figures. Several agencies mentioned related costs such as printing and software, but could not provide specific figures.

Cost Savings Not Quantified

When employer programs capture a large share of total transit agency revenues, these programs should reduce the costs associated with cash handling for individual fare transactions. Although the transit agencies generally felt that some cost savings might be achieved through their programs, none was able to quantify these savings or supply a per-transaction cost of accepting cash payments.

Two agencies said that specific programs reduced cash handling to a high degree. King County Metro made this comment in regard to their monthly pass programs, which sell approximately 46,000 passes per month to employers and to retail outlets who sell them to individuals. Most passes are distributed through retail outlets, and employers can participate on generally the same terms as grocery and drug stores that sell them to patrons. WMATA said the same about its Smart Benefits program, in which transit benefits can be downloaded directly by the employee onto a stored value card. Both of these programs reduce pass distribution costs. Several agencies commented that they believe annual pass programs could hold down costs because they reduce the number of passes to be printed and distributed per year. However, they did not have comparative data between annual and monthly passes.

Ridership, Revenue, and Cost Impacts Differ by Program Type

Universal and monthly pass programs, both of which are fairly common program types, have different impacts on ridership, revenues, and costs. Table 5 compares general indicators from the three conventional universal pass programs (King County Metro's Flex Pass, RTD's Eco Pass, and VTA's Eco Pass) to the three conventional monthly pass programs (MARTA's Partnership Program, King County's Consignment Retail Pass, and Metro Transit's TransitWorks!). It appears that, on the whole, universal pass programs are more effective at serving a greater number of employees by focusing on larger employers. However, the programs often require more staff to administer, are more complex, and generally are designed to be revenue neutral. In contrast, monthly pass programs are more effective at increasing revenues and reaching many employers, but tend to serve many small to moderate size employers.

Table 5. Comparison of Universal and Monthly Pass Programs

	Universal Pass	*Monthly Pass*
Pricing structure	More complex—price is negotiated or tiered based on location of employer	Generally simple and standardized, although may involve discounts for larger purchases of passes
Employer characteristics	Generally serve employers that are moderate to large in size (average of 50–490 employees per employer)	Typically serve employers that are relatively small to moderate in size, on average (average of 15–100 employees per employer)
Number of employers/ employees	Generally cover fewer employers (80–1,000)[a] but more employees (40,000–50,000)	Generally serve more employers (200–500) but fewer employees (12,000–30,000)
Staffing	2.5 FTEs or more to administer	1–2 FTEs to administer
Ridership	Account for 5–15 percent of total ridership	Account for 3–10 percent of total ridership[b]
Impact on revenues	Generally designed to be revenue neutral	Generally designed to increase revenues when ridership increases

a. The Denver RTD program has more than 1,000 employers, but the other two have far fewer (80 and 200). Since the Denver program requires 3.6 FTEs to administer it, the number of FTEs required to serve employers works out about even.

b. The percentage of ridership for Atlanta was not available from MARTA staff; the research team estimates it at less than 10 percent.

These results reflect program design; universal pass programs appeal to larger employers, and achieve greater ridership gains by requiring that passes be given to all employees. The comparison confirms the effectiveness of this strategy and perhaps points to different approaches based on the types of employers to be served. Universal pass programs seem to make more sense for large employers and where there is existing transit capacity. Monthly pass programs favor smaller employers and are more effective in bringing in revenue per rider.[5]

These differences may indicate that agencies can combine universal pass and monthly pass programs to reach a wider variety of employers. Both King County Metro and Metro Transit offer universal passes and a monthly pass program, and they receive the highest proportion of revenues through employer programs (more than 40 percent). However, the proportion of their ridership that comes from transit benefits recipients is in the middle of the range for this group of agencies (18–22 percent and 12 percent, respectively). Given that neither transit agency operates a rail system, and that they are not among the dense and transit-rich East Coast cities, this may point to an effective strategy for transit agencies in similar circumstances.

Further Data Needed

Many transit agencies had relatively sparse data on their employer programs in terms of effects on ridership, revenues, and costs. Additional data on the following topics should be collected so that individual agencies can better gauge success at meeting specific objectives.

Program Enrollment and Revenues

While every transit agency had good data on the number of employers enrolled, not every agency could identify the number of employee participants. For instance, the agency may only know the number of stored value cards or vouchers that are sold, but not how many employees are using them (e.g., an employee may receive one or more $20 vouchers). Likewise, transit agencies should be able to track the amount of revenue received from these programs to make the comparison with program costs to determine the program's effectiveness.

Intensity of Transit Ridership

Not every transit agency had information available on the level of ridership associated with transit benefits users. For instance, in the case of universal pass programs, employees may not ride transit at all, even though the employer has purchased a pass. Even in programs where employees elect to receive transit benefits, they may choose to ride infrequently. If transit agencies find this to be the case, they may want to look at ways to boost not only the number of participants, but the frequency with which they ride transit. Surveys of pass recipients could help answer this question.

Trend Data

Trend data showing employer and employee enrollment over time would provide a better indication of factors that have affected enrollment (i.e., whether enrollment changed in response to economic conditions or transit agency changes such as service changes or fare increases). On the micro level, it would help determine how ridership changes at participating worksites; for instance, do most impacts occur immediately after implementation of a transit benefit, or does it take several years for information to reach all employees and travel patterns can be adjusted? Compiled over several agencies at the macro level, it could help give agencies without programs some idea what to expect over time as their programs mature.

Program Costs and Cost Savings

It would be helpful to transit agencies to be able to quantify the costs of their employer programs in terms of staff and marketing budgets, but few were able to do so. These costs would enable agencies to determine whether the additional expenses of maintaining an employer benefits program are offset by the revenues brought in by the program. In addition, if agencies can demonstrate that the employer programs achieve cost savings by reaching riders more efficiently and cutting down on cash handling expenses, it would help justify the programs in case of potential cutbacks.

Conclusion and Future Research Needs

Where they exist, transit benefits programs are responsible for healthy percentages of ridership and revenues, and anecdotally they appear to have some cost advantages over individual fare media. Transit agencies should focus on better data collection, as well as conduct surveys, to optimize their existing programs and to plan new ones. Data collection could involve automated information on boardings and alightings from smart cards or other electronic fare media, or requesting that employers participating in pass or voucher programs provide more detailed information on employee enrollment, perhaps on an annual basis and by worksite. Having this data could allow transit agencies to determine more precisely what impact their programs have on ridership over time and perhaps target future marketing efforts to employers who fit the profile of employers with high participation. Surveys could help answer questions regarding employee motivations for changing (or not changing) modes, as well as to determine what proportion of employees receiving universal passes are using them to ride transit. Better data and more research could yield insights into what program types are most successful in which circumstances and to what extent transit agencies should focus on transit benefits as opposed to individual sales.

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Endnotes

[1] One metropolitan area, Seattle, is also covered by a commute trip reduction ordinance, providing yet another differentiation between transit systems. However, given the varying characteristics of the regions and the small sample size, it is impossible to say whether this played a role in the outcome of the transit agency's program.

[2] WMATA participation figures were estimated based on revenues; MARTA data estimated based on number of annual cards sold.

[3] Between 2000 and 2001, overall weekday riders increased by approximately 130,000, while commuter benefits participants increased by about 65,000.

[4] The number of VTA Eco Pass participants was estimated based on the total number of employees eligible for the program (based on employee population working for participating employers) multiplied by 0.364 since a VTA survey showed that 36.4 percent of eligible employees hold Eco Passes.

[5] The exceptions to these tendencies are MARTA and Metropass. In the case of MARTA, the discount structure makes it more attractive to large employers, since there is no discount available until an employer purchases 1,000 passes. Metropass is unusual in that it does not require employers to purchase passes for all employees, so it probably achieves lower penetration into the potential employee market.

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Bus Rapid Transit Identity: An Overview of Current "Branding" Practice

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Abstract

The emergence of new bus rapid transit (BRT) systems in recent years has prompted transit agencies across North America to establish new and unique identity programs that communicate various benefits of improved bus service. These identities and brands, however, rely largely on perception and emotional reaction, which are difficult to quantify. This lack of "hard data" makes the efficacy of identity systems and expenditures on them difficult to assess. This evaluation of 22 BRT identity programs examines the typical constructs used to establish BRT identity: visual identifiers, nominal identifiers, and color palette. Through analysis of these constructs, we find that when deployed consistently across a range of media, BRT identity may help to further build and reinforce a positive perception of BRT service and, by extension, a positive public image for public transit in general. We conclude that BRT identity must be flexible in design to accommodate future needs, plans for expansion, and technological evolution.

Introduction

Public transit is experiencing a renaissance of sorts in the United States, fueled by interest in and mandates for curbing urban sprawl, reducing traffic congestion, lessening automobile dependency, and a desire to better protect the natural environment from automobile pollution (Pucher 2001). Transit officials are working to capitalize on these changes in public consciousness, and many hope to increase the demand for public transit by improving the quality and quantity of service and, in particular, by implementing new bus rapid transit (BRT) systems, which offer passengers faster, more convenient, and more comfortable travel through service enhancements.

BRT emulates service quality offered by light rail transit (LRT) at a fraction of the infrastructural cost (Levinson 2003), and can later be useful as a means to phase in fixed transit infrastructure, such as light rail or heavy rail. Some distinguish BRT as "an incremental investment that may be the precursor to eventual implementation of rail" (Polzin and Baltes 2002, p. 60). Published research speculates that BRT, as a "new" mode of public transportation, has the potential to reduce travel times, attract new riders, and encourage transit-oriented development (Levinson et al. 2002). A Transit Cooperative Research Program report (TCRP 2003, p. 1) defines BRT in the following manner:

> BRT is a flexible, rubber-tired rapid-transit mode that combines stations, vehicles, services, running ways, and intelligent transportation system (ITS) elements into an integrated system with a strong positive identity that evokes a unique image. BRT applications are designed to be appropriate to the market they serve and their physical surroundings, and they can be incrementally implemented in a variety of environments.

We believe that the term "flexible" in the preceding definition is nonspecific, and as such would substitute the term "scalar" to better underscore the incremental and progressive nature of BRT system implementation. Perhaps more important than the exactitude of the definition, however, is the inclusion of the words "strong positive image" and "unique identity." These phrases underscore the significance of and the demand for transit planners to devise a well-conceived and consistently deployed BRT identity program to shape public perception and acceptance of BRT as a viable mode of transport that can be distinguished from existing bus service. While the mention of identity in this report is noteworthy, of equal importance is our observation that the TCRP report offers no references to other studies about BRT identity. The report cites no exemplars of BRT identity as precedents, offers little guidance as to what constitutes a BRT identity program, nor does it define the constructs of a BRT identity program. We argue that the success of any new or improved transit service, such as BRT, is dependent on the creation of an effective identity program that captures public attention and effectively conveys information about the service to its current users and potential users. In the following section we develop a clearly articulated definition of BRT identity.

Because BRT is a relatively new mode of public transit, there is a pronounced lack of qualitative and evaluative research about this service. Instead, much research has focused on quantifiable measures, such as how investments in infrastructure, vehicles and facilities, operational improvements, and technology can provide the framework for BRT service that upgrades the performance of traditional bus systems (Hess, Taylor, and Yoh 2005; Levinson et al. 2002; Polzin and Baltes 2002). Other research projects have compared the capital costs of BRT versus light and heavy rail projects and concluded that operating flexibility and lower infrastructure and equipment costs make BRT an attractive option for the expansion of public transit in mid-sized cities (U.S. General Accounting Office 2001; Sislak 2000; Wilbur Smith 1999; Euclid Consultants 1995).

Additionally, qualitative evaluation and critical assessment of both transit identity programs and BRT identity programs are conspicuously absent from the literature. Previous public transit research has investigated marketing (Bond 1984; Price Waterhouse 1998; Rosenbloom 1998), market segmentation (Elmore-Yalch 1988; Kemp 1993; Reinke 1988) and consumer perception of transit (Wachs 1976). However, while such elements of public transit marketing programs have been studied separately, comprehensive investigation of how these components interrelate with consumer perception to formulate a comprehensive transit identity program has yet to be addressed.

Despite a gap in the literature and a lack of documented case studies of transit identity, the emergence of BRT provides a unique opportunity to change negative perceptions regarding public transit in North America. However, this task is challenging without reliable, quantifiable methods that measure perception of transit-related identity. Therefore, while the approach outlined in this research is appropriate for the current stage of maturity of BRT identity, we offer this method with the caveat that as BRT service evolves and as the modes of identity communication become more complex, more pervasive, and less overt, quantifiable assessment methods and measures specific to transit should be pursued.

Despite this, our evaluation examines the current practice and effectiveness of BRT identity systems using metrics previously used to assess the perception of public transit in general, along with widely accepted models used to assess the perception of corporate identities. Throughout this evaluation, we examine the practical and perceptual constructs of identity programs specific to BRT systems.

Our assessment includes a clearly articulated definition of BRT identity through an examination of its derivative, corporate identity (which is both colloquially and erroneously referred to as its "brand"[1]); an examination of corporate identity as a precedent to BRT identity programs; and an evaluation of commonalities and trends among the representative BRT programs. Our findings lead us to argue that the desired increase in public transit ridership and the ultimate success of BRT systems depend on practical considerations of consumer perception of BRT identity.

Bus Rapid Transit Identity

BRT Identity Defined

A clear definition of our use of the term "BRT identity" requires differentiation between the concepts of identity, branding, marketing, and advertising.

Identity is a construct of recognition prescribed to an entity—a corporation, a system, an organization, and its component parts. Olins (1978) argues that corporate identity in objective terms is passive; identity is simply a mechanism to broadcast "being" or existence to a public, which helps to guide and shape public perception of that entity. Identity and the elements that constitute identity—logotypes, slogans, jingles, signature colors, marketing plans, advertising spots, and so forth—simply remind the public of the existence of a particular entity. The goal is to prompt recognition at a later date or in a different context (Olins 1990).

Branding is the application of similar constructs to a particular product or range of products. Branding is the junior cousin of corporate identity but is arguably the more pervasive and outstanding of the two. Brands and identities both provide a degree of recognition to an inanimate entity, commodity, or object. Branding generates allegiance and commonality between purveyors and consumers who are spatially removed from one another or who do not otherwise have a personal relationship (Olins 1990).

Marketing is the science of forming a strategy to create, advertise, and sustain a brand or identity. Marketing is a long-term and synergistic endeavor based on quantifiable data that aims to target specific market groups and to serve these groups as market forces demand. Market research identifies the wants and needs of the consumer and, as a result, brands and identities are often shaped with these wants and needs in mind.

Advertising is the systematic practice of convincing a consumer. Advertising activities are clearly defined by a strategic marketing plan and draw from the resources of a clearly articulated corporate identity and product brand.

Increasingly, consumers react to advertising and subscribe to brands and identities because these modes of communication represent a desired way of life or a set of ideals (Bierut, Drenttel, and Heller 2002). The constructs, definitions, and perceptual issues related to branding, identity programs, marketing, and advertising are well documented in the literature and the popular press, and research indicates that contemporary consumers do indeed react to these seemingly ephemeral prompts. We believe that much in the same manner that brands help to underscore a broader parental identity and incite trust in inanimate consumer commodities (Balmer and Wilson 1998), BRT identity programs can help to create a distinct and positive public perception of BRT while cultivating trust and reinvigorating a positive reputation for bus service.

We formulate a working definition of BRT identity that encompasses visually communicated elements (that signal consumer wants, needs, and other behaviors), strategy, and impact on industrywide identity. Though measurable, BRT identity programs (herein BRT IdP) are perceptual constructs substantiated by the strategic deployment, placement, and management of communication design elements that allow people to distinguish and remember the unique qualities of a specific BRT service from other services offered by a parent transit agency, similar services from competing agencies, and other modes of transportation altogether. In our analysis, we evaluate BRT identity programs that feature a distinct combination of communicative visual and perceptual elements that follow in the tradition of broader identity programs as they are used to delineate a BRT line from other bus services and that highlight desirable service characteristics of BRT (see Table 1). Because of this complex interrelated nature of identity, branding, advertising, and marketing, and the potential far-reaching effects of these activities on broader transportation trends (both public and private), we opt to refer to our investigation as "BRT identity," rather than simply "BRT branding."

Visual design elements usually form the collective cornerstone of any identity program, and for BRT the principal visual element is typically the BRT name represented by a logo. The logo serves as a visual prompt signifying an identity (English 1998) and supports or is supported by other design elements such as typography, unique color palettes, illustrations, and icons. Well-managed identity programs ensure proper and consistent use of visual design elements across a broad range

Table 1. Corporate Identity, Brand, Marketing and Advertising Analogs for BRT

	Corporate	*BRT*
Identity	Corporation (e.g., Proctor & Gamble, Toyota)	Parent transit agency or unique service offering (branded separately) (e.g., NFTA, Silver Line, Metro Rapid)
Brand	Product (e.g., Tide, Ivory, Prius)	Service offering (e.g., the CTA "El", NFTA MetroBus)
Marketing	Stategic plan	Ridership plan
Advertising	Print, TV, and online advertising (e.g., magazine and newspaper advertisements, commercials)	Collateral materials (e.g., trip planner, service announcements, schedules)

of outputs, media, and scale and characteristically define specific rules for use of color palette as well as the use of type, photographic images, and proper placement and management of a logo. The visual design components of a BRT IdP are usually deployed across a broad array of media at various scales; this approach can help to fully articulate an identity for a BRT system (and delineate BRT service from other services of a parent transit agency). BRT IdP can range from large-scale constructed design elements (shelter furniture and kiosk-based system maps) and large-scale environmental graphic design installations (shelter or stop signage and way-finding indicators) to smaller scale print publications (timetables and advertisements) and virtual applications (websites and television or video productions). The BRT IdP also may incorporate signature identifiers such as acronyms, formal or informal names, or graphic renditions of unique design features of BRT vehicles, iconic landscape features, or architectural landmarks. Figure 1 shows how components of a BRT IdP are communicated on a vehicle, the most common medium for communication of the BRT IdP.

Overview of Transit Identity

While BRT is relatively new, the creation of transit identity programs, and more broadly advertising, marketing, and branding public transit, is not a new endeavor. Early examples of transit identity usually served to reinforce the perceptions of a public enamored with the novelty and technological marvels of mechanized transport. Between 1910 and the late 1920s, London Transport expanded its bus and rail system and established an identity campaign that included "carefully designed lettering everywhere, and publicity, especially by posters, conveyed the message

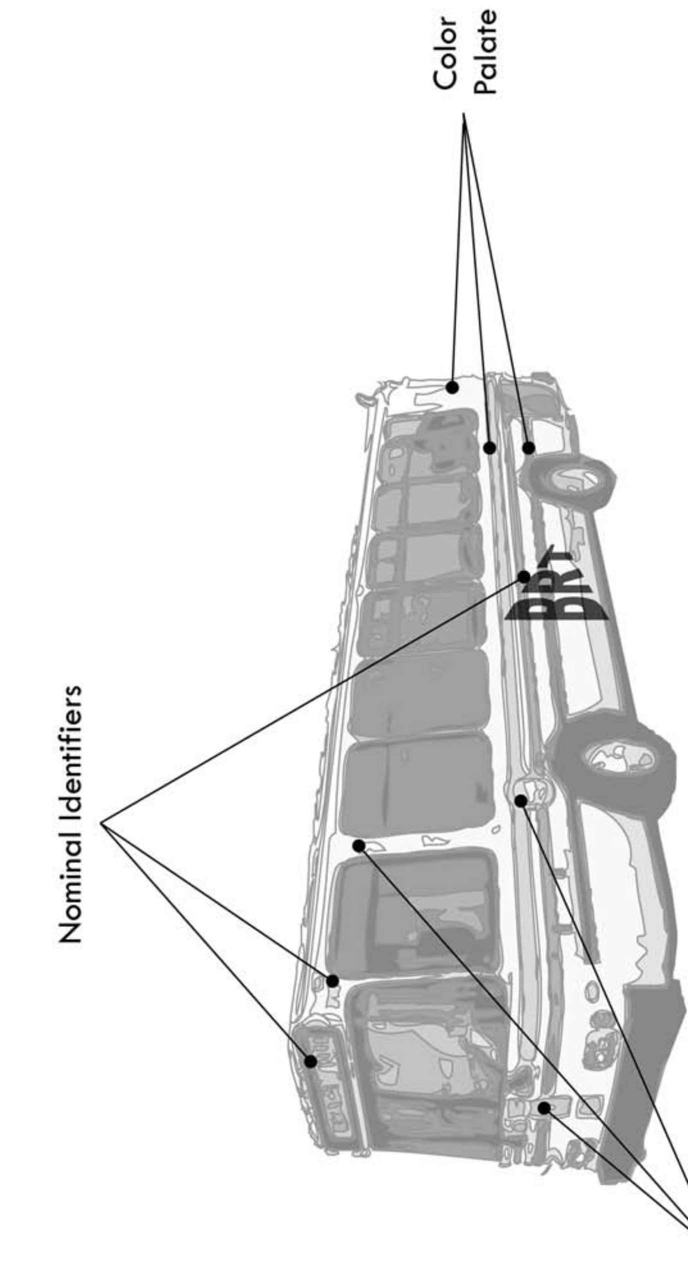

Figure 1. Components of BRT IdP as Deployed on a Vehicle

whenever the undertaking was addressing the public" (Baker and Robbins 1974, p. 250). Other notable achievements in the evolution of comprehensive transit identity programs include the 1890 colloquial adoption of the identifier "T" to signify the subway in Boston (General Drafting Company and Massachusetts Bay Transportation Authority 1977), the iconic London Routemaster double-decked buses introduced in the late 1950s, Henry Beck's 1930 London Underground map, as well as more recent examples such as Massimo Vignelli's 1970 New York City Subway map (Heller and Pomeroy 1997) and signage system, and Vignelli's 1965 Washington Metro signage (Schrag 2001).

Contemporary transit officials perhaps seek to follow the successes of previous identity efforts, and in addition, many believe that BRT holds great potential because of its lower development and implementation costs (compared to rail transit), expandability, and operating scalability.[2] Undoubtedly, this new service offering is ripe for a new marketing and consumer communication approach. An attraction of BRT is the promise that it can provide lower cost, high-quality service that retains current riders, attracts new riders (with speedier service), and gains political and taxpayer support for public transit (Polzin and Baltes 2002), and this support can be enhanced and extended through a thoughtfully developed and well-maintained BRT IdP.

The physical features of BRT vary but typically include some of the following: exclusive rights-of-way and direct routing, intersection and signal priority, improved passenger boarding, coordination with land-use planning, limited stations, frequent all-day service, prepaid fares, level boarding, unique vehicles, and the use of ITS (Levinson et al. 2002). For passengers, these features make a bus ride faster and more convenient. Typical service characteristics are highlighted in a variety of printed materials on the subject of BRT—published research, press releases, informational brochures, Internet websites—using terminology that identifies BRT as fast and convenient service that is distinct from traditional fixed-route transit. The efficacy of these physical manifestations of BRT service are discrete and are therefore easy to identify, clear to monitor, and straightforward to evaluate.

Other constructs, such as visual identity elements, are more subjective, harder to monitor, and difficult to assess, but can equally influence ridership. We describe these constructs as "perceptual." The perceptual image of public transit—that is, transit identity—can be defined as a function of vehicles, shelters, and identity. We expand on this relationship of elements to include a factor of identity deployment that is achieved through the diffusion of collateral materials—elements that communicate identity such as way-finding and directional signage, printed maps and schedules, corporate communications, advertisements, posters, flyers, and driver and transit police uniforms—as well as ephemeral materials, such as website design and television and radio advertisements. Consequently, we define transit identity in this manner:

Transit Identity = f (vehicles, shelters and stations, collateral materials)

where:

Vehicles	= color, design, functional usability, and cleanliness of vehicles
Shelters and stations	= color, design, functional usability, and cleanliness of shelters
Collateral materials	= proprietary publications such as timetables, system maps, etc.

Collectively, perceptual identifiers affect riders and potential riders on a subconscious or emotional level, and thus the efficacy of perceptual identifiers are more difficult to measure than a more clear-cut return on investment of physical features. However, if the trend with corporate identity and branding holds true for BRT identity, perceptual identifiers may be equally if not more important than physical features, and will undoubtedly act as the catalyst for changing stubborn public opinions about public transit in general. However, creating an effective identity for a BRT system is a difficult task for a variety of reasons:

- The hard-to-define nature of identity makes the creation and maintenance of an identity program challenging relative to similar exercises in the corporate world. Many of the actors who plan or evaluate BRT identity are not familiar with the process behind the development, or the demands of maintaining such an identity.
- Accountability and competition for profits drive corporate identity-making exercises. In public-sector services, such as public transit, the cycle of accountability is not as linear, occurs over a much longer period, and is not as acutely driven by profitability to the degree that corporate counterparts may be.
- Creating an identity is a collaborative effort and ideally brings together experts from transportation, urban planning, marketing, and design with

stakeholders (riders and potential riders). The multidisciplinary nature of such an exercise makes difficult an already complex endeavor, especially when paths of communication or workflows are not in place and may be more challenging to establish.

- Procedure and process among traditionally unrelated fields (e.g., graphic design and transportation planning) may also create additional obstacles related to vocabulary and time management, which may hinder the long-term demands associated with creating and maintaining a viable identity.

Research Approach

Our evaluation focuses on 22 existing BRT systems at various stages of maturity: in revenue service, under construction, in development, or planned. The 22 systems selected[3] are intended to be representative and not a comprehensive evaluation of *all* BRT systems. In addition, some systems included in our original evaluation were pilot and test programs for BRT systems that were never fully realized, or that the parent agency opted to revert to traditional bus service. These systems, however, remain in the group we evaluated, as the lessons learned from such unsuccessful attempts are equally as valuable as the successes gleaned from fully realized BRT systems.

For each BRT system evaluated, we compiled information from government data, published inventories of U.S. BRT systems (Campbell 2004; TranSystems Corporation 2004; U.S. General Accounting Office 2001), collateral materials from BRT systems, and photographic and observational data. We also consulted the Federal Transit Administration (FTA) BRT website (U.S. Federal Transit Administration 2004), which supplies information on BRT projects funded through FTA demonstration programs. In addition, we visited operational BRT systems in Boston, Denver, Los Angeles, Orlando, Pittsburgh, Seattle, Toronto, and a pilot project in Washington, D.C., and we reviewed short-term and long-range planning documents supplied by officials from several transit agencies and by partners in the design firms engaged by transit agencies. We also conducted informal interviews with transit officials, bus drivers, and environmental graphic designers who specialize in the production of identity products for public transportation. Throughout this evaluation, we use best practice examples from our examination of 22 BRT systems. Rather than relying on only the best examples from the most heavily patronized—and possibly best funded—systems, we instead chose to discuss notable examples from many systems, even those from systems where the overall BRT IdP is less developed in comparison to others.

The design of BRT identity can be expressed as a function of visual identifiers, nominal identifiers, and color palette. We have adopted a modified version of Melewar's (2003) corporate identity taxonomy to evaluate the design elements of BRT IdP. Visual identifiers include logo and other visual elements; nominal identifiers include the "official" BRT system name or the colloquial parent system name (such as the "T" in Boston or the "El" in Chicago, for example) and the typography used to represent the name; color palette includes specific colors and a method for consistent use of color and color families on vehicles, shelters, and in collateral publications such as timetables, maps, and schedules.

Similarly, the principal factors that shape consumer perception (and presumed use) of public transit in general can be summarized in the acronym SCARCE: safety, comfort, accessibility, reliability, cost, and efficiency (Gray 1992). After a careful analysis of the SCARCE items, Wachs (1976) suggests that the most important service characteristics for encouraging people to ride transit are speed and convenience. Recent research finds that the SCARCE acronym, in addition to describing customer perception of a wide range of transit services, is also applicable to BRT; an analysis of onboard surveys of BRT riders in Orlando and Miami found that customers place a high value on frequency of service, comfort, travel time, and reliability of service (Baltes 2003).

BRT IdP Assessment

Our evaluation of 22 BRT systems yields a number of recurrent approaches to identity development or deployment. Though the 22 systems we evaluated represent only a small number of those planned and/or in revenue service, the analysis offered provides a common vector for further consideration as well as for future investigation.

Visual Identifiers

Bus shelter space, vehicle placards, and most recently entire vehicle exteriors have been considered a blank slate for graphic designers and advertisers (as well as graffiti artists) and command top advertising dollar (Heller 1999). Evidence suggests that advertising wraps on both buses and rail vehicles have significantly altered public perception of most transit operations (Jarzab, Lightbody, and Maeda 2002), and few could argue that buses as moving billboards are prime advertising real estate. However, observational data suggest that transit officials and designers of BRT systems are forgoing the sale of this prime advertising space and instead using the space to fully articulate BRT IdP and "sell" public transit and BRT instead of a commercial product or service. Similarly, BRT shelter spaces are usually uncluttered by advertising, so that BRT IdP does not compete among the visual noise of a typical busy streetscape.

BRT shelters and information kiosks typically include minimal aesthetics and signage that features high-contrast sans serif type and distinctive geometrics that are easy to see and read at a distance or in inclement weather (see Figure 2), and ensure maximum readability, especially for those unfamiliar with the local language or for those with memory and cognitive impairments. In Boston, Los Angeles, and Orlando, all BRT shelters contain information-rich kiosks that provide customers with audiovisual transit information (and also draw from sustainable solar power in Los Angeles).

Likewise, vehicle aesthetics are typically visually "clean" or uncomplicated in design, and often prominently feature a simple color palette and/or only one typeface. For example, Metro Rapid vehicles in Los Angeles are painted entirely in red and white and feature a heavyweight sans serif typeface that can be read easily at a distance or while the vehicle is in motion.[4]

Like vehicle and shelter aesthetics, the design and aesthetic consideration of BRT collateral products such as schedules and websites are visually streamlined and feature careful use of color and imagery. For example, Express! The Bus in Honolulu features thoughtfully designed and intuitive graphic user interfaces (Lidwell, Holden, and Butler 2003; Norman 2002).

Our observations support research that indicates that motorists and pedestrians are more likely to see, discern, and remember a clearly marked BRT vehicle in motion than a traditional local bus (with transit agency markings and typically advertising as well), which travels at slower speeds and makes more stops to collect and drop off passengers.

Nominal Identifiers (BRT System Name and Logo)

Name, logo, and service encompass the nominal identifiers of BRT IdP. Like the aforementioned graphic elements, BRT logos are evaluated by the public in terms of geometric form, color, explicit or implied message, and use of typography. Metro Rapid, for instance, incorporates the existing and highly recognizable "M" associated with Los Angeles Metro service. Derivative nominal identifiers incorpo-

Source: Photos by authors, except Silver Line logo from MBTA.

Figure 2. BRT IdP Nominal Identifiers—Orlando Lymmo, Los Angeles Metro Rapid, Boston Silver Line

rate existing elements such as color choice, typography, or letterforms into BRT IdP. For example, the Lymmo name borrows the "Ly" from its parent transit agency LYNX, and uses a similar (but distinct) typography and color scheme. Illustrations of the four sample BRT IdPs in Los Angeles, Boston, and Orlando, along with referential information about the identity of each parent transit agency is shown in Table 2.

Usually BRT logos and BRT IdP center around typography, and typographic letterforms commonly feature or form the BRT system name, such as the planned Albany GoBus! or Metro Rapid in Los Angeles. Rarely do logos used to convey BRT IdP include acronym-based names of parent transit agencies such as MBTA, LYNX, MTA, or NFTA. Terminology used in BRT names often connotes exclusivity and first-rate or premium service more so than the names of other services offered by parent transit agencies. For example, Silver Line in Boston, Lymmo (a playful moniker for limousine), and Express! The Bus denote "premium" service levels.

Linear elements connote movement, speed, direction, and/or connection. Most of the logos evaluated incorporate some sort of distinct linear element, or manipulation of typographic elements to imply linear movement, such as the silver ribbon stripe used to identify Boston Silver Line vehicles. This linearity ensures readability as the vehicles move at high speed and implies a sense of direction or speed when the vehicles are at rest. The elliptically dotted "i" in LA's Metro Rapid graphically reads as "in motion," both when vehicles are actually moving as well as stopped. The unique ellipse appears across the Metro Rapid system on vehicles, at shelters, and in collateral materials.

Frequently, BRT lines carry names that imply speed and freedom. For instance, use of rapid in the name Metro Rapid communicates to the user that Metro Rapid BRT service is faster than typical bus service. Other BRT IdPs that feature terms that imply speed include two proposed systems, Albany GoBus! and Detroit SpeedLink, and two systems in revenue service, the Vancouver B-Line and Phoenix Rapid. The conjunctive letters X and Y feature diagonal linear elements and are often rendered in such a manner to denote speed and direction—for example, the X used in the Connextions West Busway in Pittsburgh and the Y used in the Lymmo BRT IdP in Orlando.

In some cases, place names or colloquial identifiers influence the name of BRT systems and feature prominently in BRT IdP. Examples include the Rio Hondo Connector in San Juan, the Phoenix Rapid, and the City-County Express in Hono-

Table 2. Comparison of BRT and Parent Transit Agency Identity Programs

BRT System	***Metro Rapid*** Los Angeles, CA	***Silver Line*** Boston, MA	***San Pablo Rapid*** Alameda County, CA	***Lymmo*** Orlando, FL
BRT Identity	 	 		
Parent Transit Agency	Los Angeles County Metropolitan Transportation Authority	Massachusetts Bay Transportation Authority	Alameda County Transit	LYNX—Central Florida Regional Transportation Authority
Transit Agency Identity	 			
Comments	The Metro Rapid identity is an additive or complementary identity that capitalizes on the highly recognizable M logo.	The Silver Line identity is carefully integrated into the subway identity program, but not the overall MBTA identity.		A derivative but separate identity, Lymmo is closely linked to LYNX and to LYNX and uses a similar logotype and color palette.

All images by authors, except San Pablo Rapid, courtesy of Alameda County Transit. Logos from respective transit agencies.

lulu, which has the added feature of communicating the regional scope of the BRT system.

Color Palette

Of the three design segments we evaluated, the use of color and color palette is perhaps the most complex. Our evidence indicates that mature BRT systems, such as Metro Rapid and Silver Line, make use of a well-defined, simple color palette that distinguishes BRT service from local bus service. In both Boston and Los Angeles, the color palette appears on vehicles, stations, and in collateral materials, such as timetables, system maps, and websites. Shelter spaces are uncluttered by advertising, and color is used to highlight positive and distinct features of BRT and to strengthen public perception of BRT and recognition of the BRT IdP. BRT shelters in Boston and Los Angeles use architecturally distinctive brushed steel canopies trimmed with silver (in Boston) and red (in Los Angeles). The spacious canopies used in Orlando are brightly painted and feature various colors of the Lymmo BRT IdP palette.

Transit officials clearly recognize the benefit in the careful use of a color palette for a BRT system that is distinct from the color palette used by the parent transit agency. Clearly, the use of color has proved popular in both Boston and Los Angeles. In conversations with transit officials in Los Angeles, we learned that the use of a distinct color palette for BRT has proved so effective that a "trickle down" effect has resulted in which non-BRT bus service has been redesigned to prominently exhibit a well-defined color palette that features a single color complemented by white or black. After the popular success of Metro Rapid, traditional buses serving local routes were painted bright orange and renamed Metro Local.

Less mature BRT, temporary service, and pilot programs employ color differently. Largely due to logistic reasons or economic constraints in these instances, the color palette selected to distinguish pilot BRT programs usually complements or mimics an existing color palette used by the parent transit agency. Because of this, in cases where BRT service is very new or temporary, the color palette used is not always distinct or unique from the parent. In some cases, such as the Lymmo in Orlando, parent service LYNX vehicles sometimes double as Lymmo BRT vehicles. Consequently, a fleet of vehicles designated by color as "Lymmo-only" would prove inefficient as the color palette used to identify Lymmo includes colors from the palette already used by the parent agency, LYNX.

Similarly, planners of new BRT systems have reservations about using distinct color palettes on BRT vehicles, such as in the case of the GoBus!, planned by the CDTA in Albany. Planners of GoBus! expressed reservations about using green as the signature BRT color because they believe that specially branded or color-coded vehicles are less flexible in deployment and use, and could potentially cause confusion among riders when used on other routes (TranSystems 2004).

In cases where color is used to represent BRT service as distinct from the color palette used by the parent transit authority, the colors used are often "premium" metallic colors such as silver and gold, "hot" colors or shades of red and orange, or "unique" colors not usually associated with public transit such as neon shades or pink. Nearly all BRT identities evaluated use color palettes that provide high contrast between primary and secondary or tertiary colors.

Conclusion

When establishing BRT identity programs, transit officials have the opportunity to dispel a negative perception held by some that buses are categorically inferior to rail transit and automobiles. The effective development of an identity program can overcome the notion of buses as noisy, polluting, slow, and inconvenient. Identity development is vital to the success of new BRT service because it can simultaneously combat misperceptions and communicate specific service characteristics—speedy, quiet, and environmentally responsible buses that provide greater passenger comfort than traditional buses—that may make BRT more appealing to riders. We believe this to be especially true among status-conscious consumers in the United States for whom public transit is often considered a last resort. Likewise, new identity programs for BRT can help transit systems win public approval and increase the overall demand for public transit. Increased ridership translates into increased revenue, which can be used to help fund improvements to transit systems.

Because BRT does not introduce a new vehicle type, transit systems can, especially during pilot, trial, or initial introduction of BRT service, utilize existing resources (by designating, when needed, *any* bus for use on a BRT route) and avoid the expense of brand new and/or specialized vehicles, infrastructural equipment, systems, and facilities. Transit systems can allow ridership to respond to a service introduction or modification and they can begin earning revenue before contemplating infrastructural or service expansion by beginning service with lower cost investments.

The General Accounting Office (U.S. General Accounting Office 2001) reports that a common perception detected by transit officials is the poor public image of bus service. Because of this, the stigma associated with traditional bus transit may make BRT less attractive to some potential riders. Identity elements, which can be deployed quickly at a reasonable cost, can shape a BRT IdP and improve public perception of bus transit.

BRT IdPs should strive to:

1. Use a color palette—one that clearly delineates the service as a signature offering—different from that of the parent transit agency.
2. Use nominal identifiers to underscore the following distinctive and attractive qualities of BRT:

- BRT is faster or more efficient than traditional bus service or automobile travel.
- BRT is more convenient.
- BRT is less expensive and easier than driving and parking.
- BRT can alleviate traffic congestion.
- BRT is an economic alternative to automobile ownership.
- BRT better protects the natural environment from automobile pollution.

3. Employ visual identifiers that are clear, distinct, and add value to transit facilities and streetscapes, as well as provide functional ease of use to riders regardless of age, physical ability, or cognitive ability. Visual identifiers that are high in contrast ensure readability from a distance, and allow for maximum decision-making time by all riders and potential riders. Visual identifiers that are simple to remember aid travelers unfamiliar with local service offerings or local language as well as those with cognitive or memory impairments.
4. Integrate with long-term strategic marketing and advertising plans to maximize any investments made.

Carefully planned and deployed BRT IdP can provide significant returns on investment relative to more common but less structured marketing or advertising campaigns. BRT IdP requires long-term investment and capital resources and is not a "quick-fix," silver bullet solution. A well-planned, consistently deployed, and carefully managed BRT IdP can help to change the public perception of public transit over time.

Despite the potential short- and long-term benefits that can be realized from establishing identity programs, we find it somewhat difficult to envision the broad changes that would be required of transit officials to begin undertaking consumer-driven identity development supported by marketing (Lovelock 1973). However, the very future of public transit might depend on such creative and innovative approaches, as evidenced by a *New York Times* article that reports the Metropolitan Transportation Authority's proposal to sell naming rights—as a strategy to reduce the authority's enormous deficits—to transportation facilities in the New York City metropolitan region (Luo 2004). Conducting research for, developing, and implementing identity programs may be an unfamiliar practice for transit officials who tend to focus on operations, engineering, and finance. According to Bond, "It may be difficult to think of the monolithic transit industry as a culture that responds easily to change" because of its failure to "understand the environment of change and the need for innovations" (1984, p. 39). Similarly, Oram and Stark (1996, p. 77) conclude that transit systems have uncertain experiences with marketing ventures and "tend to be either rigid and make no changes at all for several years or over experiment with lots of programs hoping that something sticks."

Our analysis leads us to conclude that above all BRT IdPs should communicate a community's vision and objectives for its public transit system (U.S. Federal Highway Administration 2003). Only together can individuals in a community collectively decide how public transit fits into growth and development scenarios for the city and region. This vision can soundly inform the development of an identity program. For example, elements of identity programs that cater to employment travel and commuting and special event and tourist travel can be appropriately emphasized in an identity program and deployed in ways that reinforce community objectives. At the very least, communities' objectives for their public transit systems would likely include abundant opportunities for access and mobility—for residents and visitors alike—that is safe and civilized.

Toward this end, BRT IdP must be designed to be scalable in terms of investment and deployment and to accommodate future expansion and changes. The opportunity to deploy components of BRT systems and BRT IdPs incrementally offers transit agencies flexibility, provided that both are designed with a degree of scalability in mind. Future research for BRT IdPs should focus on the functional usability of BRT IdP elements for a broad and diverse range of users, because if the BRT IdP is not usable, it will likely be ineffective. Future projects could also underscore the multidisciplinary underpinnings of BRT IdPs. Guidelines that engage design practitioners, transit managers, financial managers, policy-makers, usability experts, and transportation planners would help to create collaborations across disciplines and isolated sectors of the professions. A comprehensive and international inventory of transit identity programs, implementation methods, and the long-term effects of the programs could be useful for framing future research projects. Most importantly, we believe in the importance of research that quantifies how identity development or enhancement corresponds to changes in people's perception about bus service and influences ridership decisions.

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Endnotes

[1] Collectively, the elements that define transit identity facilitate the development of a specific "brand" through which brand loyalty and brand equity are developed. However, brands are built over time through consumer interaction with identity. This evaluation is concerned with the objective and communicative constructs used to communicate identity, and not with the long-term subjective and ephemeral constructs that constitute brand.

[2] An early proposal for improved bus service was developed in Chicago in 1937, and similar plans followed for Washington, D.C., St. Louis, and Milwaukee (Levinson et al. 2002). The proposals generally called for bus service along transit ways or on highway lanes designed to bring commuters to downtown areas, with the objective of improving bus travel time as city streets (and later highways) became increasingly congested. These and other plans and a report entitled "Transportation and Parking for Tomorrow's Cities" (U.S. General Accounting Office 2001) recognized the advantages of bus transit in providing access and mobility for a diffuse population. Apart from express bus service and freeway flyers in certain cities, large-scale systemwide changes to bus service proposed in early plans were seldom implemented. Instead, cities began to compete for federal "new starts" funding for rail systems, especially throughout the 1970s, 1980s, and 1990s, and

city bus service remained the status quo. Some researchers argue that the capital costs of these rail projects are disproportionately high compared to other transit investments (Pickrell 1992).

[3] The 22 systems evaluated include Silver Line, Boston; El Monte Busway and Metro Rapid, Los Angeles; Connextions West Busway, Pittsburgh; New Britain-Hartford Rapid Transit, Hartford; Southeast Corridor, Charlotte; Unnamed BRT Project (Lane Transit District), Eugene, Oregon; Express! The Bus, Honolulu; Trans2K, Oahu; South Miami Dade Busway, Miami; Line 22 Rapid Transit Corridor, Santa Clara; MAX, Las Vegas; Neighborhood Express Bus Route (NEBR), Chicago; Veirs Mills Road Bus Priority Project, Montgomery, Maryland; San Pablo Rapid, Alameda County, California; NY 5 BRT Project Go! Bus, Albany, New York; Lymmo, Orlando; Rio Hondo Connector, San Juan, Puerto Rico; Viva, Toronto, Ontario; Euclid Corridor, Cleveland; Big Blue Bus Rapid 3, Santa Monica; Downtown Express, Denver.

[4] Use of sans serif fonts in public transit identity is not without precedent; sans serif type designed in 1916 for London Transport by Edward Johnston was used for display work throughout the system (Baker and Robbins 1974).

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Valuing Transit Service Quality Improvements

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Abstract

This article investigates the value transit travelers place on qualitative factors, such as comfort and convenience, and practical ways to incorporate these factors into transport planning and project evaluation. Conventional evaluation practices generally assign the same time value regardless of travel conditions, and so undervalue comfort and convenience impacts. More comprehensive analysis of transit service quality tends to expand the range of potential transit improvement options, and justify more investments in transit service quality improvements. This article examines the value passengers place on transit service quality, summarizes research on travel time valuation, explores how transit service quality factors affect travel time values and transit ridership, and discusses implications of this analysis.

Introduction

Albert Einstein once illustrated the relativity of time by saying, "When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute and it's longer than any hour." Similarly, a minute spent in unpleasant conditions waiting for a bus may seem like an hour, while an hour spent working, resting, or conversing while traveling on a comfortable bus or train may seem pleasant or even delightful.

Qualitative factors such as travel convenience, comfort, and security affect travel time unit costs, the value users assign to their travel time, measured in cents per minute or dollars per hour. Various studies summarized in this article indicate that inconvenience and discomfort often double or triple average travel time costs. This has important implications for transportation planning since travel time costs are a major factor in transport project evaluation. How travel time is measured can significantly affect planning decisions.

Unfortunately, conventional planning practices tend to overlook and undervalue service quality impacts. The indicators used to identify transportation problems (such as roadway level-of-service ratings) and the models used to evaluate potential transport improvements focus on quantitative factors (speed, operating costs, and crash rates), and ignore qualitative factors (convenience, comfort, and prestige).

This is particularly important for transit planning because transit service quality varies from awful to good, and sometimes even delightful, and because nearly all transit service quality decisions are made in a formal planning process. A motorist who values convenience and comfort can pay extra for a vehicle with features such as automatic navigation systems, extra comfortable seats, optional safety equipment, sophisticated sound systems, and even heated cupholders. On the other hand, public transit is usually provided as a basic level of service. It is not usually possible to pay extra for higher quality service, such as a nicer waiting area or a less crowded vehicle. Such service quality improvements are made only if planners are able to demonstrate their value.

These omissions undervalue many cost-effective transit service improvements, such as more comfortable vehicles, reduced crowding, nicer stations, improved walkability, better user information, improved security, and marketing and promotion. Improving transit service quality:

- benefits existing transit passengers (who would use transit even without the improvements);
- benefits new transit passengers (who would only use transit if service is improved);
- benefits society by reducing traffic problems (congestion, roadway and parking costs, consumer costs, accidents, energy consumption, and pollution emissions);
- provides scale economies (increased ridership can create a positive feedback cycle of improved service, increased public support, more transit-oriented land use, and further ridership increases); and
- benefits transit agencies by increasing fare revenue.

This article investigates the value passengers place on transit service quality, summarizes research on travel time valuation, examines how transit service quality factors affect travel time values, discusses implications of this analysis, and recommends additional research. This information should be useful for planners interested in finding cost-effective ways to improve transit service and increase transit ridership.

Quantifying Travel Time Values

Numerous studies have quantified and *monetized* (measured in monetary units) travel time costs (Mackie et al. 2003; Wardman 2004). Travel time unit costs are generally calculated relative to average wages, with variations reflecting different factors discussed below (Waters 1992; Litman 2006).

- Commercial (paid) travel costs should include driver wages and benefits, and the time value of vehicles and cargo reflecting efficient use of assets and ability to meet delivery schedules.
- Personal (unpaid) travel time unit costs are usually estimated at 25 to 50 percent of prevailing wage rates.
- Travel time costs tend to be higher for uncomfortable, unsafe, and stressful conditions (Brundell-Freij 2006).
- Travel time costs tend to increase with income, and tend to be lower for children and people who are retired or unemployed (put differently, people with full-time jobs usually have more demands on their time and so tend to be willing to pay more for travel time savings).
- A moderate amount of daily travel often has little or no time cost, since people generally seem to enjoy a certain amount of daily travel (Mokhtarian 2005). Recreational travel and errands that involve social activities often have minimal cost or positive value.
- Unit time costs tend to increase if trips exceed about 20 minutes in duration or total personal travel exceeds about 90 minutes per day.
- Travel time costs increase with variability and arrival uncertainly (Cohan and Southworth 1999), and tend to be particularly high for unexpected delays (Small et al. 1999).
- Walking and waiting time unit costs are two to five times higher than in-vehicle transit travel time (Pratt 1999, Table 10-12). Transfers tend to

impose extra costs (called a *transfer penalty*) due to the additional effort they require, typically equivalent to 5 to15 minutes of in-vehicle travel time (Horowitz and Zlosel 1981; Evans 2004).

- Under pleasant conditions walking, cycling, and waiting can have low or positive value, but under unpleasant conditions (walking along a busy highway or waiting for a bus in an area that seems dirty and dangerous) their costs are significantly higher than in-vehicle time.
- People have diverse mobility needs and preferences, so improved options allows individuals to choose the best one for each trip. For example, some people prefer driving while others prefer transit travel; having both available allows people to select the option that minimizes costs, including travel time costs, and maximizes benefits (Novaco and Collier 1994).

The following two factors are particularly important for analysis in this article:

1. Transit travel conditions, and therefore transit travel time unit cost values, are extremely variable. Under pleasant conditions (comfortable, clean, quiet, and safe vehicles and waiting areas), transit travel time unit costs are lower than driving because passengers experience less stress and are able to rest or use their time productively. However, if transit conditions are unpleasant, transit travel times are significantly higher than automobile travel.
2. In most communities a portion of transit travelers are captive—people who are unable to drive and so are forced to use transit regardless of service quality. However, transit will only attract discretionary travelers (those who could drive for a particular trip, also called *choice riders*) if high service quality reduces unit travel time costs relative to automobile travel.

These factors have significant implications for transit project evaluation, as summarized in Table 1. More accurate analysis of these impacts tends to increase the recognized costs of degraded transit service quality, and increase the recognized benefits of transit service quality improvements.

Li (2003) describes how these factors tend to favor automobile commuting:

> An auto commute is attractive in most courses of perceived travel time, compared to a public transportation commute. It is most likely a door-to-door service, thus minimizing the number of commute stages [transfers]. It spends time predominantly on the ride episode, usually with seats secured and even entertainment (e.g., music) of the commuter's choice. It demands the

Table 1. Factors Affecting Travel Time Costs

Factor	*Description*	*Transit Evaluation Implications*
Waiting	Waiting time is usually valued higher than in-vehicle travel time.	Transit travel usually requires more waiting, often along busy roads, with little protection.
Walking links	Time spent walking to vehicles is usually valued higher than in-vehicle travel time.	Transit travel usually requires more walking for access.
Transfers	Transfers impose a time cost penalty.	Transit travel often requires transfers.
Trip duration	Unit costs tend to increase for trips that exceed about 40 minutes.	Transit travel tends to require more time than automobile travel for a given distance.
Unreliability (travel time variance)	Unreliability, particularly unexpected delays, increase travel time costs.	Varies. Transit is often less reliable, except where given priority in traffic.
Waiting and vehicle environments	Uncomfortable conditions (crowded, dirty, insecure, cold, etc.) increase costs.	Transit travel is often less comfortable than private vehicle travel.
Sense of control	A person's inability to control their environment tends to increase costs.	Transit travel is often perceived as providing little user control.
Cognitive effort (need to pay attention)	More cognitive effort increases travel time costs.	Varies. Driving generally requires more effort, particularly in congestion.
Variability	Transit travel conditions are extremely variable, depending on the quality of walking, waiting, and vehicle conditions.	Transit benefit analysis is very sensitive to qualitative factors that currently tend to be overlooked and undervalued.
Captive vs. discretionary travelers	Some transit users are captive and so relatively insensitive to convenience and comfort, but discretionary travelers tend to be very sensitive to these factors.	Achieving automobile-to-transit mode shifts requires comprehensive analysis to identify service quality factors that attract discretionary travelers.

Source: Pratt 1999; Li 2003; Litman 2006.

> commuter's (i.e., driver's) continuous attention to road conditions and motor operation, rather than temporal cues or information, and hence exploits the cognitive resource for nontemporal information processing. Also, it avoids the temporal and monetary losses due to unreliable public transportation services. All these may result in a given journey perceived as shorter for an auto commute, and hence the commute experience to be more positively evaluated than for a commute with public transportation.

However, under optimal conditions transit travel can have lower unit time costs than driving, particularly if travelers can select the mode that best meets their needs and preferences. A survey of New Jersey commuters found that train users experienced less stress and fewer negative moods than drivers making similar trips, indicating the reduced effort and greater predictability of train travel (Wener, Evans, and Lutin 2006). Train commuter stress levels declined significantly after service improvements reduced their need to transfer.

A survey of U.K. rail passengers found that many use their time for productive activities such as working or studying (30% some of the time and 13% most of the time), reading (54% some of the time and 34% most of the time), resting (16% some of the time and 4% most of the time), and talking to other passengers (15% some of the time and 5% most of the time), and so place positive utility on such time (Lyons, Jain, and Holley 2007). When asked to rate their travel time utility, 23 percent indicated that "I made very worthwhile use of my time on this train today," 55 percent indicated that "I made some use of my time on this train today," and 18 percent indicated that "My time spent on this train today is wasted time." The portion of travel time devoted to productive activity is higher for business travel than for commuting or leisure travel, and increases with journey duration.

Service Quality Valuation

The value transit users (and potential users) place on service quality can be measured using stated preference surveys (which ask people how much they value a particular feature) and revealed preference studies (which evaluate the choices people actually make when facing trade-offs between various attributes). One example of this type of analysis is described below.

Research for RailCorp (an Australian rail company) surveyed train riders to assess the value they place on various service attributes. Table 2 summarizes vehicle service values, measured by the additional fares or time travelers would willingly bear in exchange for a 10 percent improvement (from 50%–60% acceptability ratings). For example, travelers indicated that they would willingly pay 5.6¢ per minute or tolerate a 0.38-minute increase in onboard travel times in exchange for such a 10-point improvement in train layout and design.

Table 3 presents the additional fare or onboard time train travelers would be willing to pay for a 10 percent improvement of various station attributes. For example, travelers expressed willingness to pay 2.4¢ per minute or tolerate a 16-minute increase in their onboard travel times in exchange for such a 10-point improvement in train layout and design.

Table 2. Value of Train Improvements

Type of Train Improvement	*Additional Fares (2003 Aust. Cents per Minute)*	*Additional Onboard Time (Additional Time in Minutes)*
Layout and design improvements	5.6¢ (2.2%)	0.38 (1.0%)
Cleanliness	3.8¢ (1.5%)	0.26 (0.7%)
Ease of train boarding	3.2¢ (1.2%)	0.22 (0.6%)
Quietness	3.2¢ (1.2%)	0.22 (0.6%)
Train outside appearance	2.3¢ (0.9%)	0.15 (0.4%)
On-train announcements improved	2.3¢ (0.9%)	0.16 (0.4%)
Heating and air-conditioning	2.2¢ (0.8%)	0.15 (0.4%)
Improved lighting	1.9¢ (0.7%)	0.13 (0.4%)
Smoothness of ride	1.5¢ (0.6%)	0.10 (0.3%)
Graffiti removed	1.2¢ (0.5%)	0.08 (0.2%)
Seat comfort	1.1¢ (0.4%)	0.07 (0.2%)

Source: Douglas Economics 2006.

Table 3. Value of Station Improvements

Type of Station Improvement	*Additional Fares (2003 Aust.Cents per Minute)*	*Additional Time (Increased Onboard Time in Minutes)*
Tickets	2.4¢ (0.9%)	16 (43.2%)
Cleaning	1.9¢ (0.7%)	13 (35.1%)
Station building	1.4¢ (0.5%)	10 (27.0%)
Staff	1.3¢ (0.5%)	9.0 (24.3%)
Ease of train on and off	1.1¢ (0.4%)	8.0 (21.6%)
Platform surface	1.0¢ (0.4%)	7.0 (18.9%)
Station announcements	0.8¢ (0.3%)	5.0 (13.5%)
Safety	0.8¢ (0.3%)	6.0 (16.2%)
Signing	0.7¢ (0.3%)	5.0 (13.5%)
Graffiti	0.7¢ (0.3%)	5.0 (13.5%)
Retail	0.7¢ (0.3%)	5.0 (13.5%)
Platform seating	0.6¢ (0.2%)	4.0 (10.8%)
Lifts/escalators	0.4¢ (0.2%)	3.0 (8.1%)
Information	0.4¢ (0.2%)	3.0 (8.1%)
Station lighting	0.4¢ (0.2%)	3.0 (8.1%)
Bus	0.3¢ (0.1%)	2.0 (5.4%)
Bike	0.3¢ (0.1%)	2.0 (5.4%)
Toilets	0.2¢ (0.1%)	1.0 (2.7%)
Car park	0.2¢ (0.1%)	1.0 (2.7%)
Car park drop-off	0.2¢ (0.1%)	1.0 (2.7%)
Platform weather protection	0.1¢ (0.0%)	0.4 (1.1%)
Subway/overbridge	0.1¢ (0.0%)	0.1 (0.3%)
Taxi	0.1¢ (0.0%)	0.1 (0.3%)
Telephone	0.1¢ (0.0%)	0.1 (0.3%)

Source: Douglas Economics 2006.

Riders were also surveyed concerning their perceived cost of crowding. Crowded seating increases travel time costs by 17 percent, as shown in Table 4. Thus, 20 minutes of crowded seating would increase the generalized journey time by 3.4 minutes (20 x 0.17). In dollar terms, crowded seating adds 2¢ per minute if time is valued at $9.46/hr.

Table 4. Value of On-Train Crowding

Crowding	Crowding Cost (2003 Aust. Cents per Minute)	Crowding Factor (Additional Time)
Crowded seat	2.0¢	17%
Stand 10 mins or less	5.0¢	34%
Stand 20 mins or longer	11¢	81%
Crush stand 10 mins or less	11¢	104%
Crush stand 20 mins or longer	17¢	152%

Source: Douglas Economics 2006.

Crowding factors were expressed as a function of train passenger *load factors* (passengers divided by seats). Below an 80 percent load factor (80 passengers per 100 seats) no crowding costs are incurred. At 80 percent, crowding begins to impose costs. At 100 percent, the additional crowding factor is 0.1, increasing onboard travel time unit costs by 10 percent, from 14.08¢ per minute (the uncrowded seating value of time) to 15.49¢ per minute, an increase of 1.41¢ per minute. Loads of 160 percent add an additional crowding factor of 0.6 minutes or 8.45¢. At 200 percent loading (the maximum number of passengers CityRail trains are considered to be able to carry), the additional crowding factor is 0.74 or 10.43¢ per minute. Above 200 percent, passengers must wait for another train.

The UK Passenger Demand Forecasting Council reached similar conclusions concerning the costs of passenger discomfort and delay (PDFC 2002). The PDFC recommends that train load factors of 1.20 to 1.40 (120–140 passengers per 100 seats) result in crowding factors of 0.14 to 0.26, compared with a 0.17 crowding factor calculated for Sydney (Douglas Economics 2006).

Crowding in accessways, stations, and platforms makes walking and waiting time less pleasant. Table 5 indicates adjustment factors for low, medium, high, and very high crowding conditions. A minute of time spent waiting under high crowding conditions is valued at 3.2 minutes of onboard train time whereas walking time is valued at 3.5 times higher (reflecting the additional discomfort and effort involved, but not the reduced walking speed caused by crowding).

Table 5. Value of Platform Waiting and Access Time

Activity	Crowding Level			
	Low (<0.2 PSM)	*Medium (0.2–0.5 PSM)*	*High (0.5–2 PSM)*	*Very High (>2 PSM)*
Waiting vs. onboard train time factor	190%	150%	320%	550%
Walking vs. onboard train time factor	220%	220%	350%	620%
Waiting value of time (2003 AU$/hr)	$18.30	$14.20	$30.30	$51.90
Walking value of time (2003 AU$/hr)	$21.00	$21.00	$32.70	$58.90

PSM = Passengers per square meter.
Source: Douglas Economics 2006.

Fruin developed six station environment crowding levels-of-service (LOS) ratings, ranging from A (no crowding) to F (extreme crowding). These costs begin to increase significantly when crowding exceeds LOS D, which occurs at a density of 0.7 passengers per square meter (PSM). Crowding has an even greater impact on walking, since it both increases costs per minute and reduces walking speeds. Level of service F, characterized by the breakdown of passenger flow, imposes crowding costs 10 times greater than level of service A.

In some situations, increased crowding costs may reduce the benefits of other transit improvements or incentives that increase peak-period ridership. For example, transit fare reductions or improved rider information may increase ridership, increasing crowding costs. These additional costs should be considered when evaluating such strategies.

Valuing Transit Passenger Information Improvements

Transit user information includes bus stop signs, printed and posted schedules, conventional and automated telephone services, transit websites (including websites designed to accommodate cellular telephones and PDAs), changeable signs or monitors at stations and stops, and announcements. Some newer systems use real-time information on the location of individual buses and trains, so signs, monitors, and websites can predict when the next vehicle will arrive at a particular stop or destination.

Many transit systems now offer real-time information (Infopolis 2 Consortium 2000; CIty-VITAlity-Sustainability 2006). This information reduces waiting stress and allows passengers to better use their time and coordinate activities (Turnbull and Pratt 2003). Dziekan and Vermeulen (2006) evaluated the effects real-time information has on tram passenger perceived wait time, feelings of security, and use in The Hague, the Netherlands. One month before, 3 months, and 16 months after implementation, the same sample of travelers completed a questionnaire. The researchers found that perceived wait time decreased by 20 percent and noted no effects on perceived security and ease of use.

Turnbull and Pratt (2003) tested real-time information signs in 1984 at several platforms on the London Underground Northern Line. The signs gave order of arrival information for the next three trains, route and terminal destination, and the number of minutes before expected arrival. The previous signs had supplied the first two of these elements of information, but not predicted arrival time. Passenger value these systems: 95 percent of respondents indicated it was useful and 65 percent reported it helped reduce waiting uncertainty. The information was used by 12 percent to select what train to take, with passengers reporting that they employed the time until arrival in selecting transfer points or choosing to wait for a close behind train that might be less crowded.

Travel Time Valuation Summary

This analysis indicates that if transit service is convenient and comfortable, unit transit travel costs are lower than for driving, since transit travelers experience less stress and can use their time to rest or work. Under such conditions, transit travel time is typically valued at 25 to 35 percent of prevailing wages, compared with 35 to 50 percent for drivers. However, disamenities such as crowding, noise, and dirt significantly increase travel time unit costs. For example, transit travel time can be valued at about 25 percent of wage rates when sitting, 50 percent of wages when standing, 100 percent of wages in a crowded bus or train, and 175 percent of wages when waiting under unpleasant conditions, such as an unsheltered bus stop adjacent to a busy roadway.

Increased transit travel speeds can be valued based on average time costs, but improvements in reliability should be valued at a higher rate, reflecting the higher unit costs of unexpected delay. Each minute of delay beyond the published schedule should be valued at three to five times the standard in-vehicle travel time (perhaps excepting a two- or three-minute grace period considered to be a "normal" delay).

Time spent walking to and waiting for transit vehicles generally has unit costs averaging two to five times higher than in-vehicle time, or 70 percent to 175 percent of prevailing wages. Improved walking and waiting conditions, such as transit area pedestrian improvements, and improved transit stop area cleanliness and security, reduces these relatively high unit costs, such as from 175 percent down to 70 percent of wage rates (from the higher to the lower end of the typical estimated cost range of these activities) or even lower, to 50 percent of wage rates if conditions are particularly pleasant, such as at an attractive transit station with real-time information, shops and services, and other convenience features. Although the value of travel time is generally lower for children than for adults, reflecting the lower opportunity cost of their time, discomfort should be valued at the same rate as adults or even higher. For example, under poor waiting conditions children's time should probably be valued at 175 percent of wage rates, or even greater, the same value applied to adult travelers under the same conditions, reflecting adults concern for their children's comfort and security.

Transfers are estimated to impose penalties equivalent to 5 to 15 minutes of in-vehicle time. This implies, for example, that a typical passenger would choose a 40-minute transit trip over a 30-minute trip that requires a transfer. This premium reflects the physical and mental effort involved, plus the relative discomfort and insecurity at a typical transit stop or station, and so may be reduced with more comfortable waiting conditions and better user information.

Table 6 illustrates "default" travel time unit cost values. These values are calculated relative to prevailing wages, adjusted to reflect LOS ratings. Roadway LOS rates are widely used for evaluating automobile travel conditions. In recent years similar rating systems have been developed for walking, cycling, and public transit service (Phillips, Karachepone, and Landis 2001; Kittleson & Associates 2003a and 2003b; Litman 2005; Victoria Transport Policy Institute 2006). The Florida Department of Transportation (2002) developed the LOSPLAN computer program to automate these calculations.

Real-time transit vehicle arrival signs reduce perceived wait times by approximately 20 percent. These signs also reduce unit costs of the time spent waiting because passengers experience less stress and are better able to organize their trips. A 20 percent savings therefore represents the lower bound value of cost savings from such systems, provided that the information is easy to access and reliable.

Table 6. Recommended Travel Time Values

Category	LOS A-C	LOS D	LOS E	LOS F	Waiting		
					Good	Average	Poor
Commercial vehicle driver	120%	137%	154%	170%		170%	
Commercial vehicle passenger	120%	132%	144%	155%		155%	
City bus driver	156%	156%	156%	156%		156%	
Personal vehicle driver	50%	67%	84%	100%		100%	
Adult car passenger	35%	47%	58%	70%		70%	
Adult transit passenger—seated	35%	47%	58%	70%	35%	50%	125%
Adult transit passenger—standing	50%	67%	83%	100%	50%	70%	175%
Child (<16 years)—seated	25%	33%	42%	50%	25%	50%	125%
Child (<16 years)—standing	35%	46%	60%	66%	50%	70%	175%
Pedestrians and cyclists	50%	67%	84%	100%	50%	100%	200%
Transit transfer premium					5-min.	10-min.	15-min.

Source: Based on Waters 1992; Litman 2006.

Table 7 describes how to value the travel time savings of various types of transit service improvements. Such improvements can be particularly effective at shifting travel from automobile to transit if implemented in conjunction with other incentives such as commute trip reduction programs, parking cash-out, and marketing programs (Victoria Transport Policy Institute 2006).

Table 7. Valuing Service Improvements

Improvement	Methodology
Faster travel	Travel time savings.
Reduced crowding	Reduce time unit costs from high to average.
More comfortable vehicles	Reduce in-vehicle time unit costs.
Improved waiting conditions	Reduce the high time unit costs typically assigned to waiting.
Improved walking conditions	Reduce the high time unit costs typically assigned to walking.
Improved coverage area	Reduced walking travel time.
Real-time arrival information	Reduce waiting time unit costs.
Faster vehicle loading	Reduce wait and travel time costs.
More frequent service	Reduce wait time costs.
Reduced transfers	Eliminate transfer premium.
Increased travel reliability	Reduce the high time unit costs assigned to unpredictable delays.
Improved user information	Surveys to determine their value and impacts on ridership.
Improved status	Surveys to determine their value and impacts on ridership.

Travel Impacts

Many examples exist of specific service improvements that increase transit ridership and reduce automobile travel (Evans 2004; Wall and McDonald, 2007). Discretionary transit users (people who have the option of driving) tend to be particularly sensitive to comfort and convenience improvements (Phillips, Karachepone, and Landis 2001; Litman 2004; DfT 2006).

Transport modelers use *generalized cost* (total monetary and time costs) coefficients to predict how changes in vehicle operating costs, fares, and travel speeds affect travel behavior. The Transportation Research Laboratory (2004) calculates generalized cost elasticities of –0.4 to –1.7 for urban bus transit, –1.85 for London underground, and –0.6 to –2.0 for rail transport. Dowling Associates (2005) estimate that in Portland, Oregon, the elasticity of transit travel with respect to transit travel time is –0.129, and the cross elasticity with car travel is 0.036, meaning that a 10 percent reduction in transit travel time increases transit ridership by 1.29 percent and reduces automobile travel by 0.36 percent. Such elasticities tend to be highly variable, depending on specific demographic and geographic factors. Additional analysis is therefore needed to calibrate the impacts of transit service quality improvements on transit ridership and automobile travel in specific situations.

The elasticity of transit use with respect to service frequency (called a *headway elasticity*) averages about 0.5, meaning that each 1 percent increase in transit service frequency increases ridership by 0.5 percent. This can be used to evaluate how reductions in waiting time unit costs are likely to affect ridership.

Currently, public transit is usually supplied with low service quality and fares to provide basic mobility for physically, economically, and socially disadvantaged people. Because most public transit service relies on direct public financial subsidies (unlike automobile travel, which relies on more indirect subsidies, such as the value of public lands devoted to road rights-of-way, free parking provided by governments and businesses, and external accident risk and pollution costs), public officials are reluctant to fund transit service improvements that may be considered excessive and wasteful.

As a result, transit fails to satisfy the demands of travelers willing to pay more for higher service quality. Market studies indicate that a portion of current automobile users will shift to transit if the service is comfortable and convenient (Project for Public Spaces and Multisystems 1999; TranSystems Corporation 2005), and are willing to pay higher fares. Where public transit offers basic quality service with low fares, it is used mainly by transit-dependent people, typically representing 5 to 10 percent of its potential market. However, where service quality is high (comfortable vehicles and stations, reliable and frequent service, walkable neighborhoods, etc.), a significant portion of discretionary travelers (people who could drive) will choose transit.

Example

Table 8 summarizes the cost reductions that result from improving the convenience and comfort of a transit trip from LOS E to LOS C by improvements such as adding sidewalks and attractive bus stop shelters, and providing seats in vehicles. As a result, the generalized cost of the trip declines 41 percent, from $14.66 to $6.69, compared with $10.14 for an automobile trip on the same corridor. Such improvements reduce the ratio of transit to automobile costs from 145 percent down to 86 percent. This represents the upper bound of cost savings from comfort and convenience improvements alone, since not all transit trips require transfers or involve travel on crowded vehicles.

Table 8. Travel Time Cost Reductions from Service Quality Improvements

	Walk	Wait	In Vehicle	Transfer	In Vehicle	Walk	Total	Fare	Generalized Cost
Transit–Current									
Minutes	5	10	20	5	15	5	60		
LOS rating	E	E	E	E	E	E			
Portion of wages	84%	70%	70%	175%	70%	84%			
Travel time costs	$1.05	$1.75	$3.50	$2.19	$2.63	$1.05	$12.16	$2.50	$14.66
Transit–Improved									
Minutes	5	10	20	5	15	5	60		
LOS rating	C	C	C	C	C	C			
Portion of wages	50%	50%	35%	50%	35%	50%			
Travel time costs	$0.63	$1.25	$1.75	$0.63	$1.31	$0.63	$6.19	$2.50	$8.69
Difference	*$0.43*	*$0.50*	*$1.75*	*$1.56*	*$1.31*	*$0.43*	*$5.98*	*$0.00*	*$5.98*
Percent change	*40%*	*29%*	*50%*	*71%*	*50%*	*40%*	*49%*	*0%*	*41%*
Automobile trip									
Minutes	1	0	30	0	0	3	34		
LOS rating	E	E	E	E	E	E			
Portion of wages	84%	0%	84%	0%	84%	84%			
Travel time costs	$0.21	$0.00	$6.30	$0.00	$0.00	$0.63	$7.14	$3.00	$10.14
Transit–current/auto									*145%*
Transit–improved/auto									*86%*

Improvements of this magnitude should increase transit ridership by about 20 percent, assuming an elasticity of transit travel to generalized costs of –0.5, about half of which would probably substitute for automobile travel. For example, an urban corridor has 12,000 total daily trips, of which 2,000 are by transit, half of which occur during peak periods. Table 9 illustrates the benefits from improving transit service LOS from E to C. These benefits include travel time cost reductions to current transit users (off-peak traveler benefits include no in-vehicle benefits, since these consist largely of reduced crowding, which is a peak-period problem), consumer surplus gains to travelers who shift mode (calculated by dividing monetized unit benefits by two, based on the rule-of-half), and reduced external costs (traffic congestion, parking subsidies, and accident risk) from reduced driving, estimated at $5.00 per trip during peak periods and $2.00 during off-peak periods (Litman 2005). The results indicate that these improvements would provide benefits that average more than $10,000 per day, or more than $350,000 annually.

Table 9. Monetized Benefits from Service Quality Improvements

Travel Changes	*Number*	*Unit Benefits*	*Total Benefits*
Peak-period riders	1,000	$5.98	$5,980
Off-peak riders	1,000	$2.92	$2,920
New peak riders	200	$2.99	$598
New off-peak riders	200	$1.46	$292
Reduced peak automobile trips	100	$5.00	$500
Reduced off-peak automobile trips	100	$2.00	$200
Total			*$10,490*

Although vehicle traffic reductions may appear small (about 2%), these service quality improvements can be implemented with other mode shift incentives, such as improved transit speeds, fare reductions, parking pricing, and commute trip reduction programs to achieve additional travel impacts and benefits (Victoria Transport Policy Institute 2006). These strategies tend to be synergistic, resulting in larger total benefits when implemented together than the sum of their individual impacts.

This illustrates how convenience and comfort improvements can significantly reduce travel time costs and provide benefits that are virtually invisible to most current transportation economic evaluation models.

Conclusions

There are many possible ways to improve transit service quality, including reduced crowding, increased service frequency, nicer waiting areas, and better user information. Current transport evaluation methods tend to focus on quantitative factors such as speed and price, and undervalue qualitative factors such as comfort, convenience and reliability. As a result, cost-effective transit improvement strategies are overlooked and undervalued, resulting in underinvestment in transit service quality improvements, making transit less attractive relative to automobile travel.

Service quality improvements that reduce travel time unit costs (cents per minute or dollars per hour) provide benefits comparable to speed improvement that reduce total travel time. For example, a service quality improvement that reduces travel time unit costs by 20 percent provides benefits equivalent to an operational improvement that increases travel speeds by 20 percent. Techniques described in this article allow service quality to be incorporated into transport planning by adjusting travel time unit costs to reflect convenience and comfort factors. The values recommended in this article can be used as defaults, although they should be calibrated for specific conditions.

This analysis indicates that with high service quality, transit travel unit time costs are lower than for driving. If service is comfortable and convenient, many people will choose transit rather than driving for some trips, even if it takes somewhat more time, since transit travel is less stressful and passengers can rest or work while traveling. However, transit is often inconvenient and uncomfortable, resulting in unit travel time costs higher than driving, which reduces transit ridership.

In a modern, affluent society consumers are accustomed to high quality goods and services. Most travelers place a high value on comfort, convenience, and reliability. Motorists are able to express these values by paying extra for more luxurious vehicles, more convenient parking, and sometimes higher quality toll roads. In contrast, individual transit passengers are generally unable to purchase higher quality service. As a result, transit does not satisfy travelers willing to pay extra for higher service quality—so they generally shift to driving. Ultimately everybody loses, since consumer demand is unmet, transit ridership declines, transit becomes stigmatized, and traffic problems increase.

This is actually good news because it indicates that there are many cost-effective ways to improve transit service quality and increase ridership that tend to be overlooked. Many transit comfort and convenience improvements are relatively inexpensive and provide additional benefits such as improved walking conditions, improved mobility for nondrivers, and support for more compact, smart growth development.

With better evaluation techniques planners can identify policies and programs that more effectively respond to consumer needs and preferences, including transit service improvements.

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Hazardous Bus Stops Identification: An Illustration Using GIS

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Abstract

Safety and accessibility to bus transit systems play a vital role in increasing transit market potential. Bus passengers often tend to cross the streets from either behind or in front of the bus as crosswalks do not exist near most bus stops, which are typically away from intersections. These unsafe maneuvers frequently result in either auto-pedestrian collisions or conflicts.

Identifying hazardous bus stops would serve as a building block to study the causal factors, select mitigation strategies, and allocate safety funds to improve bus passenger safety. The focus of this article is to develop a Geographic Information Systems (GIS) based methodology to assist decision-makers in identifying and ranking bus stops in high auto-pedestrian collision concentration areas. The working of the GIS-based methodology is illustrated using 2000–2002 auto-pedestrian collision data, traffic volumes, bus stop coverage, transit ridership data, and street centerline coverage for the Las Vegas metropolitan area. Results obtained are sensitive to buffer radius and ranking methods used to rank hazardous bus stops. Potential strategies and countermeasures to enhance safety at hazardous bus stops are also discussed.

Introduction

Increasing traffic congestion and decreasing air quality standards are growing problems in many urban areas. The quest to address these problems has been ongoing for several years. An enhanced bus transit system is one possible solution to address the growing congestion and air quality problems in urban areas. The success of bus transit systems, which depends a lot on the generated revenue, in turn depends on ridership. Transit system passengers' perception of transit system safety is very often a deciding factor as to whether one uses the system (Vogel and Pettinari 2002; Volinski and Tucker 2003). However, the bus transit market potential cannot be explored to its full extent unless issues related to safety of bus passengers (either on board or during their travel from/to the bus stop) and accessibility to the bus stops is addressed. Toolkits are being designed and developed to enhance accessibility and safety of bus stops to attract more riders and enhance systems performance (Weiner and Singa 2006; Hamby and Thompson 2006).

In general, a majority of bus transit trips begin and end with a walk trip. Studies, such as the one by Moudon and Hess (2003), have shown a strong relation between auto-pedestrian collisions and widely used transit corridors. Providing appropriate pedestrian facilities along bus transit corridors makes access to transit systems more effective. At a minimum, such facilities should include sidewalks, crosswalks, and pedestrian signals. However, facilities such as crosswalks and pedestrian signals do not exist at bus stops, which are farther away from an intersection. Lack of these facilities or having to use long circuitous routes encourages bus transit system users to cross the streets midblock from either behind or in front of the bus to board or alight a bus. These unsafe maneuvers frequently result in auto-pedestrian collisions or conflicts.

The focus of this article is to identify and rank bus stops in high auto-pedestrian collision concentration areas. Capabilities available in commercial Geographic Information Systems (GIS) software programs are explored to identify hazardous bus stops. The results obtained can be used by transit system managers to further study the causes of collisions, understand the problems, and identify strategies to better plan and operate bus transit systems. Further, the results also assist in identifying target locations for education, outreach, and enforcement to enhance safety.

Data

The data required to identify hazardous bus stops include auto-pedestrian collision data, traffic volumes, bus-stop coverage, bus ridership data, and street centerline network in a GIS format. In this study, collision data for the years 2000–2002 from the Nevada Department of Transportation (DOT) were used. One of the limitations of the collision data obtained from Nevada DOT was the lack of appropriate information to identify auto-pedestrian collisions that involved transit system users. Hence, all auto-pedestrian collisions during the period 2000–2002 were used in this study.

Traffic volumes from 2000–2002 were obtained from Nevada DOT Annual Traffic Reports. The bus-stop coverage and bus ridership data was obtained from the Regional Transportation Commission of Southern Nevada (RTC). Street centerline coverage was obtained from the Clark County GIS Manager's Office.

GIS Methodology

A GIS-based methodology was developed to identify and rank bus stops in high auto-pedestrian collision concentration areas. The GIS-based methodology involves the following steps:

1. Geocode auto-pedestrian collision data.
2. Create an auto-pedestrian collision concentration map.
3. Overlay bus-stop coverage on auto-pedestrian collision concentration map.
4. Extract the number of collisions for each bus stop in high auto-pedestrian collision concentration areas.
5. Identify traffic volumes and obtain alighting and boarding data.
6. Compute collision frequency, collision rates, and rank high-collision bus stops.

Step 1. Geocode Auto-Pedestrian Collision Data

In this step, the auto-pedestrian collision data collected are geocoded using standard features available in commercial GIS software programs. The street centerline coverage is used to address-match the collision data. As the study area is an urban area, street name/reference street name and address reference systems are used to address match collision locations.

Step 2. Create an Auto-Pedestrian Collision Concentration Map

The geocoded auto-pedestrian collisions obtained in Step 1 may show spatial clustering and dispersion across the study area. However, the presence of a dot on a GIS map does not necessarily equal one collision. Several collisions may have occurred at this point. For example, Figure 1 shows the spatial distributions of auto-pedestrian collisions along a corridor. In the example, seven auto-pedestrian collisions occurred at the Flamingo Road/Maryland Parkway intersection whereas only one auto-pedestrian collision has occurred at the Flamingo Road/Tamarus Street intersection during the study period. However, in the figure, both the locations appear as if they have only one collision each. This is because the symbols (dots in the map) for each of the collisions at one location lie on top of each other and cannot be distinguished. In other words, the map does not exactly reflect the collision concentrations of locations having more than one collision.

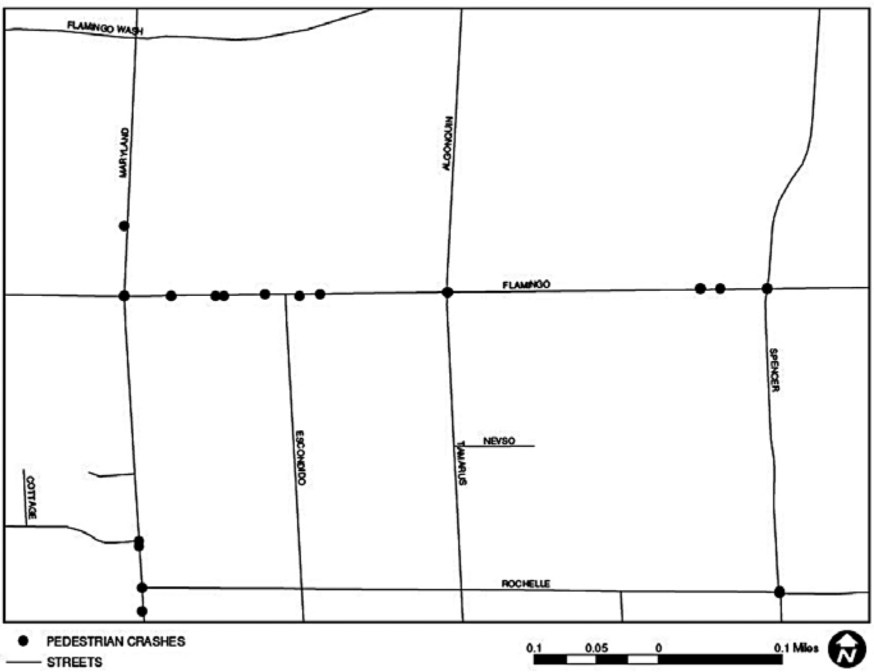

Figure 1. Spatial Distributions of Auto-Pedestrian Collisions—Points

Developing collision concentrations is extremely helpful in identifying high auto-pedestrian collision concentration areas. This can be achieved using the density map feature available in most commercial GIS software programs. The number of cells and radius are two parameters that have an affect on collision concentration. Figure 2 shows the concentration of collisions created using the Kernel Density

Method for the same corridor in Figure1. From the figure, it can be clearly seen that the Flamingo Road/Maryland Parkway intersection has a greater number of auto-pedestrian collisions when compared to the Flamingo Road/Tamarus Street, and hence by comparison is a "higher" collision concentration location. Thus, in this step, a collision concentration map is created to identify high risk areas from the geocoded auto-pedestrian collision coverage using the Kernel Density Method.

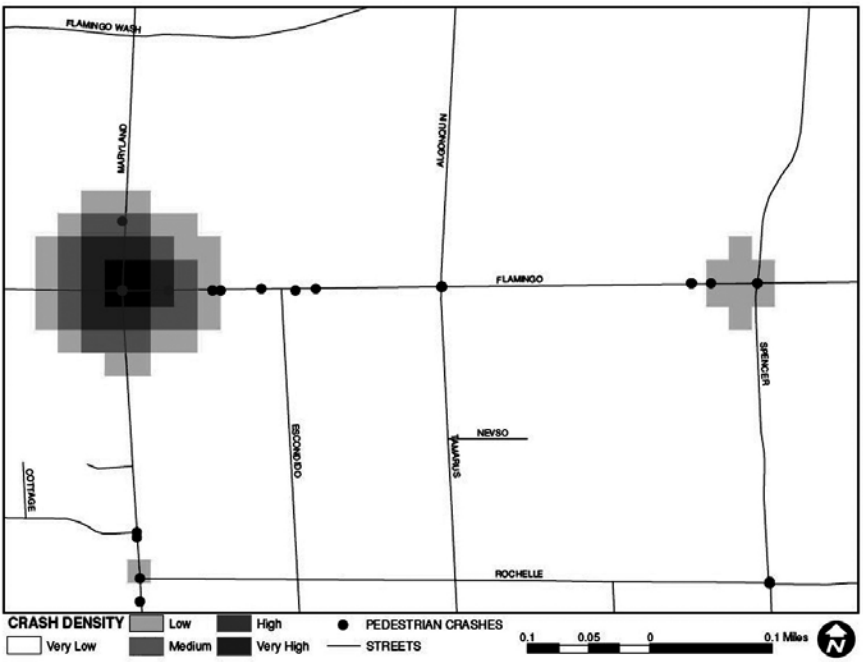

Figure 2. Spatial Distributions of Auto-Pedestrian Collisions—Concentrations

Step 3. Overlay Bus Stop Coverage on Auto-Pedestrian Collision Concentration Map

The objective of this study is to identify and rank bus stops in high auto-pedestrian collision concentration areas. In this step, bus-stop coverage is overlaid on the collision concentration map developed in Step 2 to identify bus stops in high auto-pedestrian collision concentration areas.

Step 4. Extract the Number of Collisions for Each Bus Stop in High Auto-Pedestrian Collision Concentration Areas

High auto-pedestrian collision concentration areas are classified into no-, low-, medium-, and high-risk areas. The focus of this step is to extract the number of auto-pedestrian collisions in the vicinity of each bus stop in high auto-pedestrian collision concentration areas. Bus stops that may be considered further in analyses could only be those in high-risk level areas, medium- and high-risk level areas, or low-, medium-, and high-risk level areas.

First, buffers are generated around the bus stops in selected risk-level areas using standard features available in commercial GIS software programs to identify auto-pedestrian collisions in the vicinity of each bus stop. The buffer distance should be selected such that only auto-pedestrian collisions related to and within the area of bus stop of interest are identified.

Second, the buffers are then overlaid on the geocoded auto-pedestrian collision coverage to capture the identified auto-pedestrian collisions in the vicinity of each bus stop. Clipping, which is performed to cut a portion of one layer using one or more polygons in another layer, is used to capture the auto-pedestrian collisions. The resultant layer from the clipping process is a clipped collision shape file that gives the total number of collisions which fall in all the buffers. This layer does not identify the exact buffer in which a collision falls. The join tool is then used to link the collisions with their corresponding buffer. The two databases that are joined are the clipped collision database and buffered bus-stop database. Each collision is linked with its corresponding bus-stop buffer with the help of the join tool.

Step 5. Identify Traffic Volumes and Obtain Alighting and Boarding Data

Traffic (link) volumes at each bus stop in high auto-pedestrian collision concentration areas could be collected or identified from annual traffic reports. It is generally felt that auto-pedestrian collisions are high at locations with high pedestrian activity or exposure. At bus stops, this can be easily observed by collecting data pertaining to the number of passengers alighting and boarding the bus. This step focuses on obtaining this data for each identified bus stop in high auto-pedestrian collision concentration areas.

Step 6. Compute Collision Frequency, Collision Rates, and Rank High-Collision Bus Stops

The ranking of high-collision bus stops is done using three different methods. In the first method (collision frequency), high-collision bus stops are ranked using the number of auto-pedestrian collisions in the vicinity of each high collision bus stop. For the second method (collision rate–ADT), collision rates are calculated by dividing the number of auto-pedestrian collisions per year by traffic volume in million vehicles per year. In the third method (collision rate–TP), the collision rates for each high-collision bus stop are computed by dividing the percent of auto-pedestrian collisions in the vicinity of a high-collision bus stop by the percent of transit passengers (alighting and boarding) using the same high-collision bus stop. The high-collision bus stops are then ranked based on the computed collision rates. Percent was considered as transit ridership data were not available for the same duration for each bus stop. Further, transit ridership data were not available for the same period as collision data. If such data were available, collision rates could be computed by dividing the number of auto-pedestrian collisions in the vicinity of a high-collision bus stop by the number of transit passengers (alighting and boarding) using the same high-collision bus stop during the same period. Alternatives, such as passenger survey data, may be considered if no form of alighting and boarding data are available.

Illustration and Discussion

The Las Vegas metropolitan area is considered as the study area for the illustration of the methodology. On average, the Las Vegas metropolitan area has seen more than 50 fatal auto-pedestrian collisions and 600 injury auto-pedestrian collisions per year during the last five years. This history of high incidence of auto-pedestrian collisions in the Las Vegas metropolitan area has generated awareness in the agencies (City of Henderson, City of Las Vegas, City of North Las Vegas, Clark County, and the Nevada Department of Transportation) that govern the area.

Previous research (Pulugurtha and Nambisan 2002, 2003) on auto-pedestrian collisions in the study area indicated that motorists' failure to yield is a major contributing factor of auto-pedestrian collisions at intersections, whereas pedestrians' failure to yield is a major contributing factor of auto-pedestrian collisions at midblock locations (collisions on streets which are greater than 100 feet away from a cross street). Observations also show that a majority of auto-pedestrian collisions are outside the resort corridor and along high speed/high volume arterial streets.

A majority of these high speed/high volume arterial streets (including both major and minor arterial streets) are part of the large and extensively used local transit system [Citizens Area Transit (CAT)].

CAT began serving the citizens of Clark County in December 1992. In just under 10 years, ridership grew from 15 million riders in 1993 to 55 million riders in 2005 (RTC 2007). Special bus service is available for qualified senior citizens and the disabled. At present, the CAT system consists of 51 routes served by 365 buses. Average daily passenger ridership during a weekday has risen to 180,000 during the last five years, a growth rate twice that of the national average. The significantly high percent of auto-pedestrian collisions due to pedestrians' failure to yield at midblock locations and bus stops being far away from intersections indicate that transit system users contribute to a notable proportion of auto-pedestrian collisions at bus stops.

The auto-pedestrian collision data for 2000–2002 were obtained and geocoded using a commercial GIS software program. As stated above, one of the limitations of this data was the lack of information to identify auto-pedestrians that involved transit system users. Hence, all auto-pedestrian collisions were considered in this study. Figure 3 depicts 2000–2002 auto-pedestrian collisions in the Las Vegas metropolitan area. An auto-pedestrian collision concentration map was then created using the Kernel Density Method. Using a trail-and-error procedure, it was determined that a cell size of about 0.25-mile and radius in the range 100 to 500 feet is appropriate for generation of an auto-pedestrian collision concentration map. Figure 4 depicts an auto-pedestrian collision concentration map developed for the Las Vegas metropolitan area. The collision concentration area was divided into four risk-level areas: no-risk level (less than 1 auto-pedestrian collision per unit area), low-risk level (1–22 auto-pedestrian collisions per unit area), medium-risk level (22–44 auto-pedestrian collisions per unit area), and high-risk level (44–66 auto-pedestrian collisions per unit area).

To identify high-collision bus stops, the bus-stop coverage was overlaid on the auto-pedestrian collision concentration map. Figure 5 shows the overlaid bus-stop coverage on the collision concentration map.

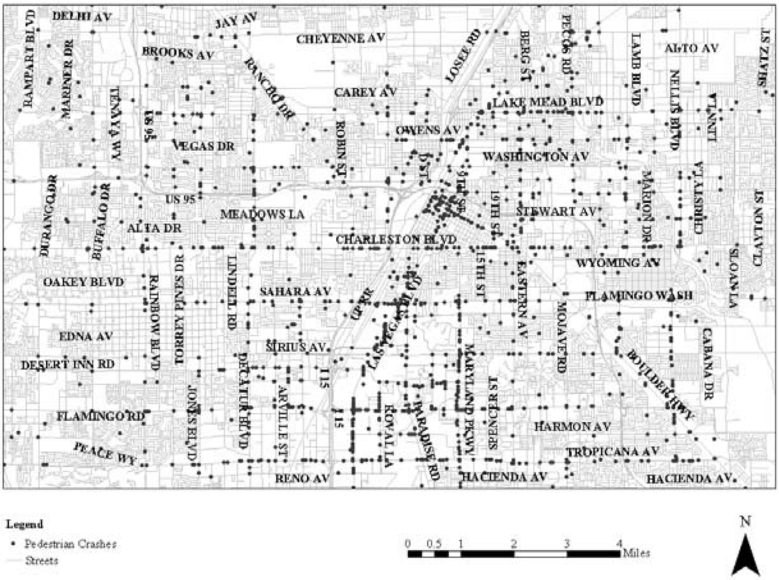

Figure 3. Spatial Distributions of Auto-Pedestrian Collisions in Las Vegas

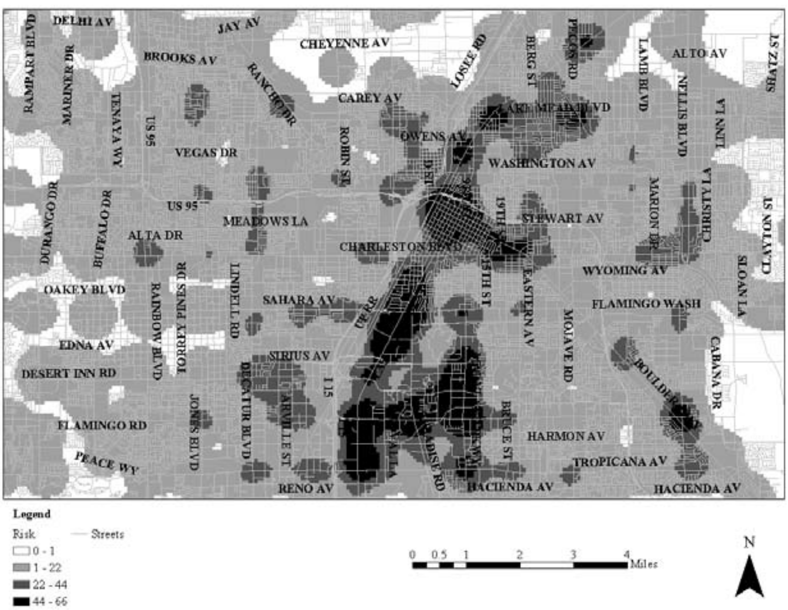

Figure 4. Las Vegas Auto-Pedestrian Collision Concentration Map

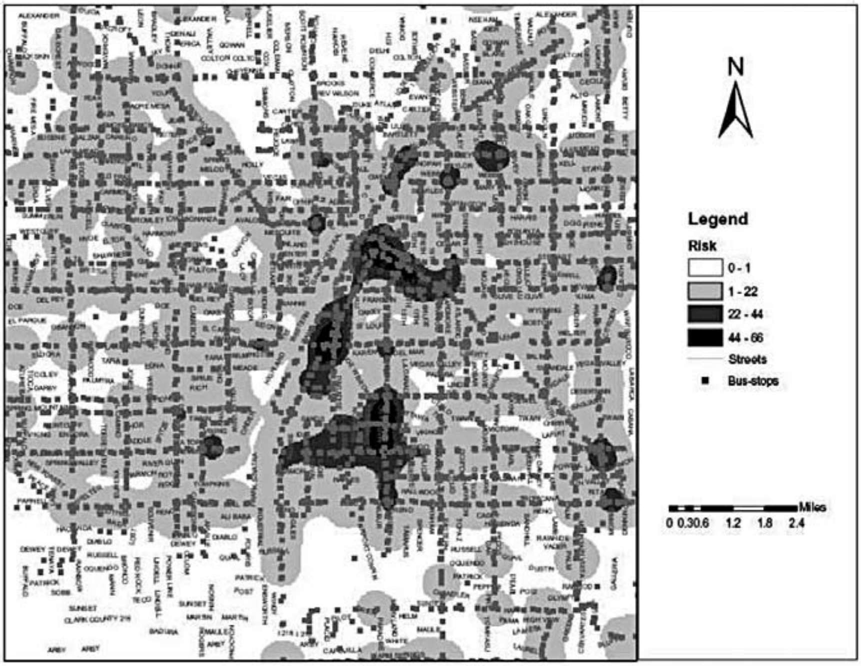

Figure 5. Bus Stop Coverage Overlaid on Auto-Pedestrian Collision Concentration Map

For illustration purposes, all the bus stops in low-, medium-, and high-risk areas were considered for further analysis. Buffers of 100 feet and 200 feet in radius were generated around each bus stop and tested for inconsistency and use. Clipping was done to capture and estimate the number of auto-pedestrian collisions in the vicinity of each bus stop in low, medium, and high auto-pedestrian collision concentration areas. It was observed that several bus stops have seen more than four auto-pedestrian collisions in their vicinity. Tables 1 and 2 show bus stops with two or more than two auto-pedestrian collisions and five or more than five auto-pedestrian collisions when buffers were generated using a 100-foot and 200-foot radius, respectively. Data from the tables show that the number of auto-pedestrian collisions identified using a 200-foot radius was on average 50 percent higher than when a 100-foot radius was used.

Table 1. High Auto-Pedestrian Collision Bus Stops when Buffer Radius = 100 Feet

S. No.	*Route #*	*Stop #*	*Stope Name*	*# Pedestrian Crashes*	*Rank Based on Crash Frequency*
1	1062	150	Rancho Dr.-Lake Mead Bl.(S)	5	1
2	1062	220	Rancho Dr.-Bonanza Rd.(S)	5	1
3	1071	660	7th St.-Fremont St.(N)	4	3
4	3021	151	L.V.Bl.S.-Circus Circus (M)	4	3
5	1081	220	Main St.-L.V.Bl.S.(N)	3	5
6	1091	160	Maryland Pky.-Sierra Vista Dr.(N)	3	5
7	1092	290	Maryland Pky.-University Rd.(S)	3	5
8	2113	290	Carey Ave.-Belmont St.(E)	3	5
9	3011	280	L.V.Bl.S.-Oakey Bl.(S)	3	5
10	70021	100	L.V.Bl.S.- Riviera Hotel(M)	3	5
11	1011	320	Rainbow Bl.-Gowan Rd.(N)	2	11
12	1132	350	L.V.Bl.N.-Mesquite Ave.(At)(Op)	2	11
13	1032	360	Decatur Bl.-Edna Ave.(N)	2	11
14	1032	390	Decatur Bl.-Spring Mtn Rd.(S)	2	11
15	1032	557	Decatur Bl.-Reno Ave.(S)	2	11
16	1061	250	Rancho Dr.-Vegas Dr.(N)	2	11
17	1072	80	Fremont St.-15th St.(E)	2	11
18	10512	170	M.L.K. Bl.-Lake Mead Bl.(S)	2	11
19	10512	286	Casino Center Bl.-Wyoming Ave.(N)	2	11

Table 2. High Auto-Pedestrian Collision Bus Stops when Buffer Radius = 200 Feet

S. No.	*Route #*	*Stop #*	*Stop Name*	*# Pedestrian Crashes*	*Rank Based on Crash Frequency*
1	3012	105	L.V.Bl.S.-Sahara Ave.(N)	11	1
2	1092	210	Maryland Pky.-Sierra Vista Dr.(S)	8	2
3	70021	100	L.V.Bl.S.-Riviera Hotel(M)	8	2
4	3021	151	L.V.Bl.S.-Circus Circus(M)	8	2
5	1092	230	Maryland Pky.-Twain Ave.(S)	7	5
6	2104	250	Lake Mead Bl.-L.V.Bl.N.(W)	7	5
7	1062	150	Rancho Dr.-Lake Mead Bl.(S)	6	7
8	1091	130	Maryland Pky.-Twain Ave.(N)	6	7
9	2033	345	Twain Ave.-Maryland Pky.(E)	6	7
10	2154	390	Bonanza Rd.-M.L.K. Bl.(W)	6	7
11	1052	170	M.L.K. Bl.-Lake Mead Bl.(S)	5	11
12	1071	640	Fremont St.-Maryland Pky.(W)	5	11
13	1072	51	Fremont St.-7th St.(E)	5	11
14	1072	70	Fremont St.-Maryland Pky.(E)	5	11
15	1081	200	Paradise Rd.-Sahara Ave.(N)	5	11
16	1092	70	Maryland Pky.-Fremont St.(S)	5	11
17	1151	170	Nellis Bl.-Charleston Bl.(N)	5	11
18	2023	160	Flamingo Rd.-Tuscany Hotel(M)	5	11

High-collision bus stops identified were different (comparing the list of bus stops in Tables 1 and 2) when different radius were used to extract the number of collisions. Inconsistency in rankings was also observed. Differences in the results obtained indicate that the number of collisions estimated is sensitive to the considered radius. Most farside and nearside bus stops are constructed such that they are 75 to 150 feet away from intersections. Considering a buffer radius greater than 100 feet may increase the likelihood of capturing auto-pedestrian collisions that (1) may not involve transit system users and their related activity, and (2) may fall in the vicinity of another bus stop at the same intersection. Based on the results obtained from the GIS analyses and that the influence area should be reasonably small, 100 feet is recommended for use in these types of studies.

Field visits show that all 19 high-collision bus stops identified using 100-foot buffers are either farside or nearside bus stops in the vicinity of signalized intersections with crosswalks. These intersections are reasonably well designed with appropriate sight distances and serve typical left-turn, through, and right-turn movements. The speed limit along the corridors with high-collision bus stops was either 35 mph or 45 mph. Actual traffic speeds at these bus stops varied from -5 to 5 percent of the speed limit. Sample field observations indicate that the purpose of more than 95 percent of pedestrian trips within 100 feet of these bus stops is transit system related. Collision rate–ADT for each bus stop was computed by dividing the number of auto-pedestrian collisions per year at each bus stop by the corresponding traffic volume (average daily traffic, ADT × 365 days) in million vehicles.

Pedestrian exposure or number of alighting and boarding passengers could be different at bus stops. Considering this could play a vital role in the ranking process. Alighting and boarding passenger data were not available for the study area during the study period. However, RTC has conducted surveys during the study period to collect samples of transit ridership data at bus stops in the Las Vegas metropolitan area. The number of surveys conducted varied from one bus stop to another. Due to lack of better data, the survey data was utilized to measure pedestrian exposure at bus stops selected using collision frequency method. As the number of surveys conducted at bus stops was inconsistent, the percent of total transit passengers (alighting and boarding) was computed by dividing the average number of passengers alighting and boarding a bus by the total average number of passengers alighting and boarding a bus at all selected bus stops and then multiplying it by

100. Likewise, percent of auto-pedestrian collisions in the vicinity of a bus stop was computed by dividing the number of auto-pedestrian collisions at a bus stop by the total number of auto-pedestrian collisions at all selected bus stops and then multiplying it by 100.

Collision rate–TP for each bus stop was then computed by dividing the percent of auto-pedestrian collisions by the percent of passengers alighting and boarding a bus. Table 3 shows route number, stop number, stop name, number of auto-pedestrian collisions in its vicinity, rank based on collision frequency, location of bus stop (farside or nearside), speed limit in miles per hour traffic volume (ADT), collision rate–ADT, rank based on collision rate–ADT, average number of alighting passengers, average number of boarding passengers, total number of transit passengers, percent of auto-pedestrian collisions, percent of transit passengers, collision rate–TP, and rank based on collision rate–TP. Several locations have the same rank when ranked using collision frequency method. However, ranks for bus stops were different when collision rate–ADT and collision rate–TP methods were used. As collision rate–TP method accounts for pedestrian exposure, this is recommended for use in ranking hazardous bus stops.

Table 3. Computation and Comparison of Ranks Using Different Methods

S. No.	Route #	Stop #	Stop Name	# Auto-Pedestrian Collisions	Rank Based on Collision Frequency	Bus Stop Location	Speed Limit (mph)	Traffic Volume (ADT)*
1	1062	150	Rancho Dr.-Lake Mead Bl.(S)	5	1	Farside	45	38,067
2	1062	220	Rancho Dr.-Bonanza Rd.(S)	5	1	Farside	45	50,500
3	1071	660	7th St.-Fremont St.(N)	4	3	Farside	35	12,400
4	3021	151	L.V.Bl.S.-Circus Circus (M)	4	3	Nearside	35	57,833
5	1081	220	Main St.-L.V.Bl.S.(N)	3	5	Farside	35	12,100
6	1091	160	Maryland Pky.-Sierra Vista Dr.(N)	3	5	Farside	35	41,700
7	1092	290	Maryland Pky.-University Rd.(S)	3	5	Farside	35	37,333
8	2113	290	Carey Ave.-Belmont St.(E)	3	5	Farside	35	15,400
9	3011	280	L.V.Bl.S.-Oakey Bl.(S)	3	5	Nearside	35	41,667
10	70021	100	L.V.Bl.S.- Riviera Hotel(M)	3	5	Nearside	35	57,833
11	1011	320	Rainbow Bl.-Gowan Rd.(N)	2	11	Farside	45	14,400
12	1132	350	L.V.Bl.N.-Mesquite Ave.(At)(Op)	2	11	Nearside	35	14,900
13	1032	360	Decatur Bl.-Edna Ave.(N)	2	11	Nearside	45	45,833
14	1032	390	Decatur Bl.-Spring Mtn Rd.(S)	2	11	Farside	45	37,000
15	1032	557	Decatur Bl.-Reno Ave.(S)	2	11	Nearside	45	30,500
16	1061	250	Rancho Dr.-Vegas Dr.(N)	2	11	Farside	45	42,700
17	1072	80	Fremont St.-15th St.(E)	2	11	Farside	35	12,400
18	10512	170	M.L.K. Bl.-Lake Mead Bl.(S)	2	11	Farside	35	30,400
19	10512	286	Casino Center Bl.-Wyoming Ave.(N)	2	11	Nearside	45	21,467
				54				

*ADT is an average value obtained using 2000, 2001, and 2002 data except for locations with S. No. 2, 3, 6, and 18. For locations with S. No. 2, 6, and 18, ADT is an average value obtained using 2000 and 2001 data. For location with S. No. 3, ADT is an average value obtained using 2000, 2001, and 2002 data from the closest count station on the street with bus stop. Source: Nevada DOT Annual Traffic Reports.

Collision Rate–ADT	Rank Based on Collision Rate–ADT	Transit Passengers (TP)			% Auto-Pedestrian Collisions	% Transit Passengers	Collision Rate–TP	Rank Based on Collision Rate–TP
		Boarding	Alighting	Total				
0.12	7	5	3	8	9.26	7.24	1.28	8
0.09	8	2	2	4	9.26	3.62	2.56	2
0.29	1	1	7	8	7.41	7.24	1.02	10
0.06	13	10	6	16	7.41	14.48	0.51	17
0.23	2	4	3	7	5.56	6.33	0.88	14
0.07	12	3	2	5	5.56	4.52	1.23	9
0.07	10	1	5	6	5.56	5.43	1.02	10
0.18	3	0	2	2	5.56	1.36	4.09	1
0.07	11	2	1	3	5.56	2.71	2.05	3
0.05	17	4	8	12	5.56	10.86	0.51	17
0.13	5	1	2	3	3.70	2.71	1.36	5
0.12	6	0	3	3	3.70	2.71	1.36	5
0.04	19	4	4	8	3.70	7.24	0.51	17
0.05	16	3	4	7	3.70	6.33	0.58	16
0.06	15	0	2	2	3.70	1.81	2.05	3
0.04	18	2	2	4	3.70	3.62	1.02	10
0.15	4	3	3	6	3.70	5.43	0.68	15
0.06	14	2	2	4	3.70	3.62	1.02	10
0.09	9	1	2	3	3.70	2.71	1.36	5
		48	63	111	100.00	100.00		

Mitigation Strategies

Mitigation strategies or countermeasures need to be identified to improve safety at bus stops and attract more transit riders. In general, bus stops should provide a safe and pleasant environment for passengers. Bus stops with greater than average daily boardings should have shelters, landscaping, and adequate lighting (Volinski and Tucker 2003; Meyer and Miller 2000). Bus-stop design should minimize conflicts with motorized traffic as well as with other nonmotorized users such as bicyclists in bike lanes or pedestrians walking past passengers waiting to board a bus.

Alighting passengers from the bus should be guided to cross the road from behind the bus rather than from in front of it. This would enable passengers to see the oncoming traffic. Pedestrians and commuters should also be guided not to walk near the bus or cross the road by walking near the bus. The likelihood that the bus driver would notice such pedestrians and commuters walking near the bus is low. This may lead to a fatal collision involving the transit bus and the pedestrian or commuter.

Some potential mitigation strategies to improve road safety and make a bus transit system more attractive are listed below.

1. Provide signs on the road, along the road, and near the bus stop encouraging commuters to cross the road using the crosswalk at the nearest intersection (if a midblock crosswalk does not exist near the bus stop).
2. Provide an audio message (announcement) directing/encouraging alighting passengers to make use of the nearby crosswalk.
3. Provide crosswalks near the bus stop if there are no crosswalks 500 feet downstream or upstream of the location.
4. Wherever feasible, use farside bus stops rather than nearside bus stops as farside bus stops discourage passengers from crossing in front of the bus in comparison to nearside bus stops.
5. Build bus turnouts wherever feasible so that the alighting passenger has a clear vision of the approaching traffic when looking to cross the road. Reentering into the mainstream traffic is relatively difficult for bus drivers at bus turnouts. This will have an adverse impact on bus operations and schedule adherence. Such adverse impacts are low at farside bus turnouts in comparison to nearside bus turnouts.

6. Provide education on the risk of crossing streets with or without inadequate facilities using television, flyers, and brochures. Information should include high-collision bus stops.
7. Conduct enforcement at identified high-collision bus stops and study/advertise its effectiveness.
8. Channel pedestrian movement to crosswalks wherever feasible.
9. If sidewalks do not exist along bus routes, construct sidewalks to the nearest intersection or section of existing sidewalk.
10. Construct overpasses near bus stops with high pedestrian activity. A benefit-cost study should be conducted to look at this option. The need for a large right-of-way and the likelihood of being underutilized as overpasses typically require out-of-direction travel by pedestrians should be considered in the benefit-cost study.

Conclusions

This article presents a GIS-based methodology to identify bus stops in pedestrian high-collision concentration areas. The bus-stop coverage was overlaid on the developed collision concentration map to identify high-collision bus stops. Use of 100-foot and 200-foot buffer radius were studied to extract auto-pedestrian collisions in the vicinity of high-collision bus stops. High-collision bus stops were then ranked using collision frequency method. Inconsistency in rankings was observed when different radii were used to extract the number of collisions. Based on the sensitivity of results obtained and that the influence area should be as small as possible so as to not to capture collisions that are in the vicinity of other bus stops, a 100-foot buffer radius is recommended for use. Use of collision rate methods (based on traffic volumes and transit ridership) was also studied. Results obtained from collision rate methods were different when compared to collision frequency method or among themselves. Use of collision rate method based on transit passengers is considered more suitable as it accounts for pedestrian exposure. Possible mitigation strategies are also discussed. Transit system managers can use the list of high-collision bus stops to study the causes of collisions in detail, understand the problems, and identify strategies to better plan and operate bus transit systems that have a significant impact on congestion and air quality in urban areas. Further, results from the study also assist in identifying target locations for education, outreach, and enforcement to enhance safety.

Conditions within the study area are consistent with those to be found in many urban areas, and in communities with a wide, fast street system. Thus, the developed GIS-based methodology can be adopted to identify high-collision bus stops in such areas. Sample field observations conducted indicate that more than 95 percent of pedestrian trips in the vicinity of selected bus stops are transit-system related. However, the assumption that all auto-pedestrian collisions in the vicinity of a bus stop involve transit system users may not be true all the time as some of the collisions may have occurred due to other reasons and may not be related to the activity at the bus stop of interest. This valuable piece of information should be collected, recorded, and provided to researchers and practitioners.

Driver and pedestrian behavior could have an impact on safety and the effectiveness of implemented mitigation strategies. Though difficult to quantify and evaluate, this warrants an investigation. Also, transit trips may begin and end with a bicycle trip. These are ignored in this study as they are relatively small in number. However, the methodology developed in this study can be applied to identify hazardous bus stops based on auto-bicycle collisions.

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Modeling Participation and Consumption in the Greek Interurban Public Transportation Market

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Abstract

This article investigates the Greek household travel demand for domestic interurban public transportation using cross-sectional micro-data from a countrywide Household Budget Survey. A number of limited dependent variable models, including the Heckit, Two-Part, and Double-Hurdle models, are implemented to jointly estimate the probability of selecting a specific mode and the amount of using it. The results provide useful insight into the existence of feedback relationships between the decision-making mechanisms of mode selection and amount of usage, and they demonstrate the predominant effect of income on the demand for coaches, railways, airplanes, and coast-wise sea ferries.

Introduction

The principal objective of this article is to investigate the consumption demand of Greek households for interurban public transportation services using cross-sectional data from a countrywide Household Budget Survey (HBS). The amount of money spent by households for trip making can provide a useful metric of their travel demand for different passenger transportation modes. In particular, the magnitude of (e.g., monthly average) travel expenditures can incorporate such information as those related to the frequency and amount of trip making as well as the monetary cost of travel by each mode. The use of expenditure micro-data can facilitate the task of identifying major social and economic determinants of household budget allocation for different transportation modes. In particular, such data can allow determining different trip decision-making structures of travelers belonging to diverse economic, social, and demographic population groups and dissimilar geographical settings.

The present study concentrates on simultaneously identifying the main factors influencing the choice and usage of interurban public transportation services in Greece. The data about travel demand for air travel, coast-wise sea travel, and intercity coach and rail travel services refer to the household level and they are based on the (most recent) 2004–05 Greek HBS. The article provides an overview of the current econometric models used in the literature to estimate travel demand using micro-data on transportation expenditures. The methodological approaches employed in the current study to analyze intercity travel demand are examined, and the study data and the variables used in the model estimation are described. Results of the model estimation are presented and conclusions and policy implications are discussed.

Travel Demand Models Using Micro-data on Expenditures

Although the effects of several economic and sociodemographic factors on household travel choices have been well documented and studied using cross-sectional data from a variety of sources, very few studies have investigated the mechanisms of household spending behavior for trip making. These studies are principally based on the use of limited dependent-variable models. The most familiar type of such models is the Tobit model (Tobin 1958), which has been applied to a wide range of consumer demand studies using micro-data (Deaton 1997). Among them, Hagemann (1981) studied the household expenditures for vacation travel using the 1972–73 U.S. Consumer Expenditure Survey (CES). Nolan (2003) investigated urban household travel decisions in the Dublin area, separately with regard to petrol, bus, and taxi fares using the 1994–95 Irish HBS. Also, Thakuriah and Liao (2006) examined the household decisions on the daily short-distance (urban) overall travel expenditures using the 1999–2000 U.S. CES.

The use of Tobit models is based on the rather restrictive assumption that the same variables affect in the same way both the decisions of travelers to use or not to use a specific transportation mode and the intensity of using it. In this way, Tobit models can only capture *corner solutions*, which imply that all households are potential users and choose to use or not to use a particular mode due to lack of affordability (low income) or the high price of petrol or public transportation fare, or both (low income and high price). However, zero observations can sometimes be attributed to other factors, such as habitual (or true) nonusage of a specific transportation mode, infrequency of traveling with the particular mode, and reduced accessibility (e.g., due to lack of appropriate transportation infrastructure and public transportation services and geographical constraints, particularly in remote regions with low connectivity, such as islands).

The literature related to the treatment of potential bias in the travel demand estimation using micro-data due to the above factors is limited. Existing studies mostly concentrate on the effect of the habitual nonusage of a particular mode through application of the Heckman's two-stage sample selection estimator, also know as Heckit model or adjusted Tobit model, or the Limited Information Maximum Likelihood selection estimator (Heckman 1979). According to this methodology, the dichotomous choice of households to travel or not to travel with a specific mode dominates their decision about the intensity of using the particular mode. The Heckit model has been employed for analyzing the car petrol consumption behavior by Kayser (2000) using the U.S. Panel Study of Income Dynamics (PSID), Asensio et al. (2003a), who employed the 1990–91 Spanish HBS, and West and Williams (2007), who used the 1996-98 U.S. CES. Asensio et al. (2003b) also used the Heckit methodology for the estimation of household expenditures for urban public transportation services using the 1990–91 Spanish HBS. The solution of instrumental variable (IV) systems of travel demand equations based on micro-data can also be included in the category of the methods used for controlling the effect of selection bias (Bergantino 1997).

The present study implements the Heckit methodology for the disaggregate analysis of household expenditures for intercity passenger transportation. In addition, a different type of limited dependent variable model—the Double-Hurdle model—is employed here for comparison purposes. According to this model, the problem of potential users who do not use a transportation mode is examined with regard to factors concerning the habitual nonusage (first hurdle), as well as other factors that inhibit them from realizing a trip, such as personal or intrahousehold constraints and reduced accessibility (second hurdle). Different versions of the Heckit and Double-Hurdle modeling methodologies are considered in this study (see below), in accordance with the existence of a feedback relationship between the decision-making mechanisms on choosing to use or not to use a specific mode and the amount of using the particular mode.

Methodological Approaches of the Study

The Heckit Model and the Two-Part Model

The consumption demand equation that describes the amount of expenditures y_i made by household i for using a specific transportation mode (e.g., for purchasing petrol or buying tickets or travel cards for using public transportation services), can be described as a latent dependent variable equation, which is typically solved using Ordinary Least Squares (OLS) among the subsample $y > 0$, as follows:

$$y^*_i = x_i\beta + u \qquad (1)$$

where:

- u is the error term that is assumed to be $\sim N(0, \sigma^2)$
- x is a set of explanatory variables of the decision of each household i on the amount of expenditures to be spent
- β is the corresponding vector of coefficients

In contrast with the actual outcome (i.e., the true expenditures made by a household i), the potential outcome is a latent variable y^*_i that is only partially observed. The non-zero observation values are assumed to be true observations of the potential outcome, but zero values indicate observations for which the potential outcome is missing (latent). The zero observations do not represent zero values for the potential outcome. In contrast with the Tobit model, rather than y^* being observed when $y^* > 0$, the y^* value is assumed to be observed based on the value of a second latent variable, z^*, where:

$$z^*_i = w_i\alpha + v \qquad (2)$$

where:

- v is the error term that is assumed to be $\sim N(0, \sigma^2)$

w is the set of selection variables of the decision of each household i on whether to use or not to use a particular mode

α is the corresponding vector of coefficients

Equation (2) is typically estimated using a binary probit (or logit) model, which provides the probability of household i to travel or not to travel with a specific mode. In this case, y is only observed if $z^* > 0$. Furthermore, the model is assumed to be governed by the following observability criteria:

$$z_i = \begin{cases} 1 & \text{if } z_i^* > 0 \\ 0 & \text{if } z_i^* \leq 0 \end{cases} \tag{3}$$

Equation (1), usually referred to as the consumption or outcome equation, and equation (2), usually referred to as the participation equation, together constitute the Heckit model. In contrast with the Tobit model, the participation and the consumption part of the Heckit model do not involve the same error structure. In addition, the selection variables w are not identical to the variables x of the consumption equation. Assuming that (u, v) has a bivariate normal distribution.

$$\begin{pmatrix} u_i \\ v_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_u^2 & \rho\sigma_u \\ \rho\sigma_u & \sigma_v^2 \end{pmatrix}\right] \tag{4}$$

where:

ρ is the correlation between u and v, the conditional equation providing the consumption part of the Heckit model can be written as follows:

$$E(y_i | z_i = 1) = x_i\beta + \rho\sigma_u\left[\frac{\phi(w_i\alpha)}{\Phi(w_i\alpha)}\right] = x_i\beta + \rho\sigma_u\lambda \tag{5}$$

where:

$\lambda = \left[\frac{\phi(w_i\alpha)}{\Phi(w_i\alpha)}\right]$ is the Inverse Mill's Ratio (IMR) that denotes the nonselection hazard

If the estimate $\hat{\lambda}_i$ is significant, then $H_0 : \rho = 0$ can be rejected, which means that there is selection bias. Otherwise, the second term of equation (5) that includes the IMR is removed, and the Heckit model is reduced to the Two-Part Model (2PM), also referred to as the hurdle or complete dominance model (Duan et al. 2003).

In the 2PM, all zero observations are generated by the mode selection decision and since a household chooses a specific mode, then it would have a certain level of usage of this particular mode. This implies that there is only dominance of the selection part to the consumption part, rather than both dominance and dependence, as it is implied in the Heckit model. In such a situation, there is no systematic feedback relationship between the participation and the consumption decision of households for using a specific transportation mode. In the case of employing the 2PM with $\text{In}(y)$, the actual outcome of using a particular transportation mode can be predicted as follows:

$$E(y_i) = \Phi(w_i \alpha)\exp\left(x_i \gamma + \sigma_\gamma^2 / 2\right) \tag{6}$$

where:

- γ is the set of coefficients of the regression equation describing the amount of using a specific transportation mode
- σ_γ^2 is the variance of the regression equation

Both the Heckit and 2PM can be generally described within the following set of relationships:

$$y_i = \begin{cases} y_i^* = x_i \beta + \text{u} & \text{if } z_i^* > 0 \\ 0 & \text{if } z_i^* \le 0 \end{cases}, \quad \textit{with} \quad z_i^* = w_i \alpha + v \quad \textit{and} \quad z_i = \begin{cases} 1 \text{ if } z_i^* > 0 \\ 0 \text{ if } z_i^* \le 0 \end{cases} \tag{7}$$

The 2PM can be considered as more efficient than the Heckit when the specification conditions of the latter model are not met (i.e., $H_0 : \rho = 0$ holds). In such cases, the 2PM avoids possible sources of inefficiency that can be present in the Heckit due to multicollinearity between the IMR and the regressors of the consumption equation.

The Double-Hurdle Model

The Double-Hurdle model, proposed by Cragg (1971), provides a statistical counterpart of the aforementioned theoretical structure described in (7). More specifically, this model postulates that the usage of a transportation mode (i.e., a positive amount of expenses for it) presupposes that household members overcome two hurdles: (1) be potential users, dependent on the willingness to use the mode, and (2) actually use the mode, dependent on the ability to access the particular mode. In comparison to the rules followed in (7), the Double Hurdle model can be generally described as follows:

$$y_i = \begin{cases} y_i^* = x_i\beta + \mathrm{u} & \text{if } z_i^* > 0 \text{ and } y_i^* > 0 \\ 0 & \text{otherwise} \end{cases}, \quad \textit{with} \quad z_i^* = w_i\alpha + v \quad \textit{and} \quad z_i = \begin{cases} 1 \text{ if } z_i^* > 0 \\ 0 \text{ if } z_i^* \le 0 \end{cases} \qquad (8)$$

Such a theoretical structure can be appealing to the case of analyzing the household demand for interurban public transportation, where potential users may not be able to use a particular service for more than one reason. For instance, an individual may not want to use the intercity coach or railway (nonparticipation) because of the habit of the license-holding members to move with private car. On the other hand, it could be that the individual would like to use the intercity coach or train (i.e., he or she is a potential user), but is constrained from accessing the particular transportation service due to the absence of a station/terminal close to the area of residence or the low frequency of the related services.

A Double–Hurdle model with dependent or independent error terms u and v, referred to here as D-DHM and I-DHM, respectively, can be alternatively adopted, according to whether the hypothesis $H_0 : \rho=0$ can be rejected or not rejected, respectively. The D-DHM assumes an endogenous feedback effect from the intensity of consumption to the participation decision (Deaton and Irish 1984). In the case that the error terms u and v are independent ($\rho=0$), the I-DHM of Cragg (1971) is obtained. The Tobit model can be regarded as a nested version of the I-DHM with $\Phi(w_i\alpha)=1$. Similarly to the case of the Heckit (or 2PM), the estimation of correlation ρ is also based here on the joint bivariate normal distribution of the error terms u and v, as described in relationship (4).

Description of the Study Data and Model Variables

The present study focuses on the analysis of the domestic interurban travel behavior of households, in relation to four different public transportation modes (coach, rail, airplane, and sea ferry). The current analysis is based on fare and travel card expenditure data, as they are originated from the 2004–05 Greek HBS. Sea travel expenses involve transporting a vehicle on the ferry such that origin and destination circulation travel could be accommodated by auto or motorcycle. This survey includes information about the travel (and nontravel) expenditures made by 6,555 households (about 2/1000 of the total population), using a multilayer stratified sampling methodology to ensure the representation power of the given sample at the level of Regions (NUTS II). Due to the very small proportion of households using intercity railway services, which has resulted in a share of less than 1 percent of the total travel expenditures, coach and rail service expenses have been aggregated here into a single category (interurban land public transportation modes) to avoid potential small-sample bias problems.

Although the current study is based on cross-sectional data, it uses information about the spatial structure of prices in the model specification. Specifically, the income variable is expressed here by the total monthly household expenditures, which typically provide a proxy of the household permanent income, weighted by the region's Relative Consumer Price Index (RCPI) for each transportation mode. The RCPI is given by the ratio of the CPI for each mode (coach and rail, airplane, and sea ferry) at a specific region to the CPI for all transportation modes at the particular region.

The CPI for all transportation modes has been calculated as the weighted sum of the CPIs of urban and interurban bus and rail services, sea ferries, airline services, taxi tariffs, and automobile petrol. The corresponding weights were provided by the NSSG and they refer to the relative contribution of the monetary travel cost of each transportation mode to the total CPI for all transportation modes in 2004. The information about the regional price variations of the taxi tariffs and public transportation fares was obtained from the Greek Ministry of Transport and Communications, while the information on the regional variation of petrol prices was obtained from the Greek Ministry of Development.

In addition to the income variable, a range of other sociodemographic and economic variables has been used in the present study to represent the characteristics of each household. Also, a HBS population density index was used to demonstrate contiguous sets of local areas with varying levels of residential density and total population size (see EUROSTAT 2005). Finally, the ratio of the gross regional product to the gross domestic product as well as regional dummy variables have been used to represent local-specific effects. The population density variables and region-specific dummies can capture local effects on the range and spatial distribution of destinations, and the frequency of using sea ferry and other transportation services. Further insights into the differential behavior of traveling by different modes could be obtained by complementing HBS related to trip expenditure information with travel surveys, which can typically provide more insight into the structure of trip characteristics.

The variables used in the model estimation, their symbols, and their basic descriptive statistics are shown in Table 1. The specification of the models was based on the log-likelihood performance criteria, the convergence behavior of the likelihood-maximizing estimator, and the need for assuring the identification of the Heckit model. The participation and consumption equations basically employ the same variables. The two equations include different variables for describing household composition and economic situation (see below). These variables have been employed to demonstrate possible interaction effects of the employment of different household members and the size and aging structure of each family on the decision to choose and the amount of using a specific mode. In accordance with the standard econometric formulation of similar studies related to the analysis of household travel (and nontravel) expenditures (Bergantino 1997; Asensio et al. 2003a; Asensio et al. 2003b), the consumption equation of all interurban public transportation modes follows a semilog linear form by employing the logarithms of the dependent (monthly travel expenditures by mode) and income variables.

Table 1. Variables Used in the Model Estimation

Variable		*Symbol*	*Mean*	*Std. Dev.*
Coach and rail expenses (Euros/month)		*land*	1.559	8.613
Air travel expenses (Euros/month)		*air*	1.206	13.267
Sea travel expenses (Euros/month)		*sea*	2.736	11.739
Income variable for coach and rail users (Euros/month)		*income(l)*	2068.611	1441.663
Income variable for airplane users (Euros/month)		*income(a)*	2020.51	1393.926
Income variable for sea ferry users (Euros/month)		*income(s)*	1968.77	1358.232
Gender (male=1)	*(d)*	*sex*	0.75	0.433
Age of the head of household (hoh)		*age*	54.259	17.2
Hoh age < 30 y.o.	*(d)*	*age20*	0.075	0.263
Hoh age between 30 - 40 y.o.	*(d)*	*age30*	0.158	0.365
Hoh age between 40 - 50 y.o.	*(d)*	*age40*	0.183	0.386
Hoh age between 50 - 60 y.o.	*(d)*	*age50*	0.182	0.386
Hoh age between > 60 y.o.	*(d)*	*age60*	0.402	0.49
No car owned	*(d)*	*ncar0*	0.34	0.474
One car owned	*(d)*	*ncar1*	0.523	0.5
Two cars owned	*(d)*	*ncar2*	0.12	0.325
Three or more cars owned	*(d)*	*ncar3*	0.017	0.13
Density > 500 inhab. / sq.km and population > 50000 inhab.	*(d)*	*hden*	0.423	0.494
Density between 100 – 500 inhab. / sq.km and population > 50000 inhab. or adjacent to a densely populated area	*(d)*	*mden*	0.03	0.171
Density < 500 inhab. / sq.km and population < 50000 inhab.	*(d)*	*lden*	0.547	0.498
Hoh working full-time	*(d)*	*ftime*	0.529	0.499
Number of children (< 13 y.o.)		*up13*	0.378	0.750
Number of teenagers (between 13 y.o. and 18 y.o.)		*teen*	0.110	0.355
Number of adults		*adults*	1.797	0.563

Table 1. Variables Used in the Model Estimation (cont'd.)

Variable		*Symbol*	*Mean*	*Std. Dev.*
Both hoh, spouse and at least one other member working	*(d)*	*hhe1*	0.037	0.189
Both hoh and spouse work, no other member working	*(d)*	*hhe2*	0.181	0.385
Either hoh or spouse, and least one other member work	*(d)*	*hhe3*	0.062	0.241
Either hoh or spouse work, no other member working	*(d)*	*hhe4*	0.265	0.442
At least two members working excl. the hoh and spouse	*(d)*	*hhe5*	0.015	0.123
One member working excl. the hoh and spouse	*(d)*	*hhe6*	0.067	0.249
None working in the household	*(d)*	*hhe7*	0.373	0.484
Expenses for motorcycle purchase (proxy for ownership)	*(d)*	*motexp*	0.006	0.077
Region's share to GDP		*pgdp*	23.123	20.219
None, primary or lower secondary education	*(d)*	*ledu*	0.548	0.498
Upper secondary, post-secondary nontertiary education	*(d)*	*medu*	0.288	0.453
Higher education (all refer to the hoh)	*(d)*	*hedu*	0.163	0.369
One person, aged 65 years or more	*(d)*	*hht1*	0.109	0.311
One person, aged 30 to 64 years	*(d)*	*hht2*	0.067	0.25
One person, under 30 years	*(d)*	*hht3*	0.027	0.162
One person with children (< 18 y.o.)	*(d)*	*hht4*	0.016	0.125
Couple without children, older person aged 65 or more	*(d)*	*hht5*	0.153	0.36
Couple without children, older person under 65 years	*(d)*	*hht6*	0.089	0.285
Couple with one child (< 18 y.o.)	*(d)*	*hht7*	0.077	0.266
Couple with two children (< 18 y.o.)	*(d)*	*hht8*	0.103	0.304
Couple with more than two children (< 18 y.o.)	*(d)*	*hht9*	0.024	0.153
Single parent or couple with at least one child > 18 y.o.	*(d)*	*hht10*	0.236	0.425
Any other type of household	*(d)*	*hht11*	0.1	0.3
Number of members active occupied		*eam*	1.005	0.957
Ownership of second residence	*(d)*	*seres*	0.189	0.392

d indicates dummy variable (0 or 1)

Results of the Estimation

The first hypothesis tested in this study refers to the similarity of the decision-making mechanisms of mode selection and usage, in terms of the existence of significant correlation between the error terms of the two (participation and consumption) equations. According to the results of the maximum likelihood ratio tests (see Table 2), the error terms of the participation and consumption equations in both types of limited dependent variable models are found to be zero correlated, based on the 5 percent significance level of the x^2 distribution, for the cases of land and air transportation, in contrast with the case of sea transportation. Namely, these findings fail to reject the hypothesis that the 2PM and I-DHM, where the decision to choose a specific transportation mode does not affect the amount of using it, are acceptable alternatives to the Heckit and D-DHM, respectively, where the decision to choose a specific mode is influenced by the amount of using it, for coach and rail and airplane, in comparison to the sea ferry.

Table 2. Results of the Maximum Likelihood Ratio Test (under the null hypothesis of zero correlation between the error terms of the participation and consumption equations in the two types of models)

Dependent Variable	*Type of Models*	*Maximum Likelihood Ratio Test Results*[a]
land	Heckit – 2PM	$\chi^2(1) = 0.15$, $p > \chi^2 = 0.699$
	D-DHM – I-DHM	$\chi^2(1) = 2.50$, $p > \chi^2 = 0.114$
air	Heckit – 2PM	$\chi^2(1) = 0.75$, $p > \chi^2 = 0.386$
	D-DHM – I-DHM	$\chi^2(1) = 1.96$, $p > \chi^2 = 0.162$
sea	Heckit – 2PM	$\chi^2(1) = 9.46$, $p > \chi^2 = 0.002$
	D-DHM – I-DHM	$\chi^2(1) = 157.34$, $p > \chi^2 = 0.000$

a. $\chi^2(1)_{.05} = 3.841$

The selection of the I-DHM for the case of coach and rail and airplane implies that participation and consumption decisions for these modes are not made simultaneously, and the utility related to the amount of using these modes does not significantly affect the decision to choose them. Moreover, the selection of the 2PM for these modes reinforces the above result, implying that the decision to choose coach and rail and airplane is separate from the amount of using them. On the contrary, a significant relationship exists between the utility of selecting and using sea ferries. This relationship can be attributed to the features of the particular mode, such as operating speed and frequency of services, the highly seasonal character of the sea travel demand and, especially, the concept of many holiday-makers that the journey by sea ferry toward islands constitutes part of their vacation. Furthermore, the outcome of the likelihood ratio tests demonstrates that sample selection bias is not a significant problem in the case of coaches and railways and airplanes in comparison to the case of sea ferries.

Table 3 presents the estimated parameters of the participation equations of the 2PM and I-DHM for the intercity land and air passenger transportation categories, and the Heckit and D-DHM for the sea passenger transportation category. The effects of the explanatory variables on the mode selection decisions are generally found to be similar between the 2PM and the I-DHM (for land transportation, and, particularly, for air transportation) and the Heckit and the D-DHM (for sea ferries), in terms of both their direction and significance. This outcome signifies that there is no other significant factor (hurdle) that influences the selection of interurban public transportation modes, except of nonparticipation and corner solutions. In particular, the income variable has a significant positive impact on the selection of coach and train, airplane, and sea ferry.

The presence of children, teenagers, males, and older persons (as household heads) and, particularly, couples without children with the oldest person aged 65 or more (*hht5*) reduces the probability of selecting one of these transportation modes. These results signify the impact of personal and intrahousehold constraints, mostly related to aging structure, on the mode selection in the specific market. On the contrary, high population densities, second home ownership, and higher education level increase the probability of selecting these modes. The effect of other variables is mixed between different modes. More specifically, the number of private cars tends to decrease the probability of selecting coach and train, but it increases the probability of selecting sea ferry and airplane (when number of cars <3). Motorcycle purchase expenses are found to have a significant positive effect on selecting land and sea passenger transportation modes in comparison to selecting airplane. Hence, private vehicle owners have an increased propensity to select sea ferry, since such a mode allows origin and destination circulation travel by their own car or motorcycle.

Table 3. Estimated Parameters of the Participation Equations

	land	*air*	*sea*	*land*	*air*	*sea*
	2PM	*2PM*	*Heckit*	*I-DHM*	*I-DHM*	*D-DHM*
income(l,a,s)	0.460**	0.613**	0.490**	0.334**	0.613**	0.440**
sex	-0.175**	-0.075	-0.122**	-0.229**	-0.075	-0.157**
age30	-0.553**	-0.221	-0.192**	-0.530**	-0.221	-0.192**
age40	-0.387**	-0.253*	-0.204**	-0.339**	-0.253*	-0.195**
age50	-0.477**	-0.328**	-0.345**	-0.431**	-0.328**	-0.319**
age60	-0.623**	-0.134	-0.422**	-0.501**	-0.134	-0.403**
ncar1	-0.436**	0.128	0.173**	-0.530**	0.128	0.106
ncar2	-0.758**	0.048	0.215**	-0.835**	0.048	0.168*
ncar3	-0.852**	-0.045	0.497**	-0.879**	-0.045	0.441**
medu	0.088	0.257**	0.314**	0.101	0.257**	0.312**
hedu	0.151**	0.284**	0.369**	0.142*	0.284**	0.364**
mden	0.354**	-0.323	0.278**	0.359**	-0.323	0.371**
hden	0.101*	0.152*	0.081*	0.100	0.152*	0.088*
ftime	-0.239**	0.001	-0.256**	-0.149	0.002	-0.278**
up13	-0.171**	-0.102*	-0.111**	-0.155*	-0.102*	-0.106**
teen	-0.033	-0.246**	-0.141**	-0.011	-0.245**	-0.137**
adults	0.010	-0.234**	-0.108**	0.006	-0.234**	-0.139**
hhe1	0.216	-0.067	0.165	0.317*	-0.067	0.201
hhe2	-0.083	0.173	0.193*	-0.038	0.173	0.206*
hhe3	0.138	-0.040	0.271**	0.227	-0.040	0.296**
hhe4	0.017	-0.107	0.087	0.039	-0.107	0.087
hhe5	-0.125	-0.006	-0.236	-0.057	-0.006	-0.226
hhe6	-0.075	0.022	0.169*	-0.007	0.022	0.169*
motexp	0.610**	-0.075	0.926**	0.594*	-0.075	0.939**
seres	0.354**	0.036	0.257**	0.358**	0.036	0.270**
pgdp	0.002	-0.026**	-0.001	-0.005	-0.026**	-0.001

* indicates $0.05<p$-value<0.1
** indicates p-value<0.05, using the t-test statistics

Table 4 shows the estimated parameters of the consumption equations of the 2PM and I-DHM for the intercity land and air passenger transportation categories, and the Heckit and D-DHM for the sea passenger transportation category. In contrast with the participation equations (see Table 3), the explanatory variables of the consumption equations of the 2PM and I-DHM (for land and air transportation) and the Heckit and D-DHM (for sea ferries) are not always found to have the same effect on travel demand in terms of both their direction and significance. Thus, there are possibly significant additional factors that affect the amount of using the Greek interurban public transportation modes, except those of nonparticipation and corner solutions. Namely, there are underlying factors that do not allow potential users to actually use these public transportation services.

Table 4. Estimated Parameters of the Consumption Equations

	land	*air*	*sea*	*land*	*air*	*sea*
	2PM	***2PM***	***Heckit***	***I-DHM***	***I-DHM***	***D-DHM***
income(l,a,s)	0.182**	0.146**	0.406**	0.999**	0.543**	0.572**
sex	-0.046*	-0.044**	-0.045**	0.175	-0.035	0.039
age30	-0.190**	-0.086**	0.094	-0.303	-0.216	0.182
age40	-0.145**	-0.099**	0.126	-0.328	-0.298	0.156
age50	-0.146**	-0.107**	-0.068	-0.261	-0.368	-0.061
age60	-0.211**	-0.066*	0.105	-0.644	-0.275	0.148
ncar1	-0.127**	-0.014	0.275**	0.390*	-0.302	0.425**
ncar2	-0.231**	-0.009	0.211	0.406	-0.190	0.327*
ncar3	-0.330**	-0.051	0.538**	-0.052	-0.513	0.704**
hden	0.029	0.031*	-0.078	-0.028	0.106	-0.084
mden	0.150**	-0.049	0.202	0.102	0.352	-0.373
ftime	-0.092**	-0.017	0.144	-0.668**	-0.340	0.189
motexp	0.341**	-0.009	0.181	0.363	0.466	0.261
pgdp	0.001	-0.007**	0.023**	0.028	-0.001	0.032**
medu	0.038	0.041**	0.067	-0.074	-0.039	0.111
hedu	0.078**	0.064**	0.144	0.184	0.146	0.192*
hht1	-0.102**	0.075**	-0.280	-0.355	-0.398	-0.592**
hht2	-0.027	0.119**	-0.216	0.505	-0.254	-0.277
hht3	0.244**	0.016	0.133	0.345	-0.419	0.332
hht4	-0.074	-0.029	-0.071	-0.149	2.089**	-0.352
hht5	-0.045	0.061*	0.202	0.094	-0.153	0.185
hht6	-0.083**	0.066**	0.341**	0.321	0.063	0.362*
hht7	-0.189**	0.078**	0.333**	-0.612	0.246	0.331*
hht8	-0.181**	0.029	0.192	-0.397	0.158	0.185
hht9	-0.167**	0.021	0.108	-0.107	0.503	0.040
hht10	-0.057*	0.014	0.017	-0.530**	-0.213	0.005
eam	0.003	0.01	-0.059	-0.041	0.037	-0.081
seres	0.122**	-0.001	-0.057	0.060	-0.104	-0.031

* indicates $0.05<p$-value<0.1
** indicates p-value<0.05, using the t-test statistics

Such factors can be related to personal, intrahousehold, and geographical constraints, as well as accessibility conditions, which are associated with the service and infrastructure characteristics of each individual mode. These situations may arise due to car unavailability, needs for escort trips involving children and elderly people, reduced connectivity of public transportation services in low-density areas and isolated regions (e.g., islands), and shortage of ferry services in winter season. The major factor that positively and significantly affects the usage of all interurban public passenger transportation modes is income, as in the case of mode selection. This outcome verifies that all these modes are normal goods (i.e., their usage increases as income levels increase). The Double Hurdle models produce larger income coefficients for all modes in the consumption equations than those produced by the Heckit and 2PM approaches. On the contrary, the latter models generally produce larger income coefficients in the participation equations than those produced by the former models. These differences imply that income plays a more significant role in travel expenditures when the market demand curve is estimated over the entire population (travelers and nontravelers), as in the Double Hurdle models, rather than when the relevant population consists only of travelers, as in the Heckit and 2PM models.

Among other factors, the increase of age is found to reduce the amount of using air and land passenger transportation modes. In all models used in the study, car ownership and motorcycle purchase expenses are found to positively affect the amount of sea travel. This outcome verifies the complementary relationship between private vehicle and sea ferry. On the other hand, car ownership is found to have a negative impact on the amount of air travel, which implies the substitution relationship between airplane and car usage for long-distance trips. Also, the 2PM demonstrates a significant negative influence of car ownership on the amount of using coach and rail, while the I-DHM shows such a negative effect only in the case of high car ownership levels (>2 cars).

Moreover, couples with children, as they are represented by variables *hht7*, *hht8*, and *hht9*, have a negative influence on the amount of coach and rail travel, but a positive influence on the amount of air and sea travel, in all models. Other household characteristics, which are not explicitly represented in the current model specification, could be having an impact on the selection and intensity of using different interurban public transportation services. In particular, the travel behavior of couples with children may be related to the pricing structure of transportation companies, which is implicitly captured here through the spatial variation of prices, and the value of time, which is partially represented by the income variable. This is because such households may consider care-giving costs, which, although they are independent of travel costs, can influence mode choice in favor of faster travel modes (i.e., airplane in comparison to coach and rail), as it was obtained from the estimation results.

Conclusions and Policy Implications of the Study

This article provided an econometric analysis of the interurban public transportation demand of Greek households. Two modeling approaches pertaining to different assumptions about consumer behavior were implemented based on the micro-data of the 2004 Greek HBS. These approaches refer to (1) the Heckit or 2PM, dependent on whether there is feedback between the participation and consumption decisions, and (2) the Double Hurdle model with dependent or independent errors. The major difference between these two types of limited dependent variable models lies in the treatment of zero observations. The decision about the selection of the appropriate model to be implemented by researchers employing similar datasets based on Household Budget (or Consumer Expenditure) Surveys is not straightforward, and direct comparison of the results is difficult to be made. This is because the Heckit and 2PM models only include travelers, while the Double Hurdle models use all observations. The study results provide valuable insights into how such different assumptions can affect theoretical developments in travel behavior and modeling. The Double Hurdle models can be considered as more general than the Heckit and 2PM approaches, since, unlike the latter models, they assume that some nontravelers could be induced to use a transportation mode if some changes were to occur in their sociodemographic situation or economic status. Likewise, travelers may stop using a specific mode if they undergo changes in some of the above factors. On the other hand, the Heckit and 2PM models investigate such changes at the one or the other direction only for the existing population of travelers.

The significant differences observed in the estimated coefficients of the consumption equations of the two types of models suggest that there are possibly other factors than those related to corner solutions and habitual nonparticipation, which affect the amount of using interurban public transportation modes. Such factors can refer to personal, intrahousehold, geographical, and accessibility constraints. The identification of these factors help better explain the reasons for which some potential users do not actually consume public transportation service. The increase of income level was found to significantly and positively affect both the participation and consumption decisions for all modes. Other factors such as car ownership, motorcycle purchase expenditures, age, household composition, residential density, and education level were also found to significantly influence public transportation demand in diverse ways. The estimation results reject the existence of feedback relationship between the selection and amount of using coach and rail and airplane, in comparison to the sea ferry, where the two decisions are found to be correlated. This relationship possibly reflects the formation of consumption habits and a positive utility associated with the sea travel.

The study results have several implications concerning those involved in public transportation policy making and planning. These implications refer to the design and evaluation of suitable measures for different transportation market segments at three levels of policy. The first and most general policy level corresponds to the entire population of travelers and nontravelers, and it relates to the results of the Double Hurdle models. The second policy level corresponds to the whole population of travelers, and it relates to the Heckit and 2PM models. The third policy level concerns specific target groups of potential or actual travelers, based on, for example, their household, income, education, or employment status, and dependent on whether the market demand curve is estimated over the entire population (of travelers and nontravelers). Particularly in the context of the Greek interurban public transportation market, the present results suggest that the increasing levels of car ownership are likely to have a positive impact on the modal share for sea ferry, in comparison to that for coach and rail and airplane. Current demographic trends related to the rapid aging of the population are also expected to adversely affect the usage of air and land passenger transportation modes. Targeted measures for promoting air and sea travel are anticipated to be mostly acceptable by families with children.

The demand models described in this study can be regarded as belonging to the family of trip generation models. Therefore, substitution or complementarity relationships between different transportation modes are not explicitly represented in these models, except of the effect of private vehicle ownership on interurban travel demand. Nonetheless, the modal share of urban travel can arguably affect decisions concerning the participation and consumption of interurban public transportation modes. These effects may be related to seasonal demand variations (vacation vs. nonvacation periods), and involve access-related complementarity and activity- or destination-based substitution among urban and interurban transportation modes. An appropriate treatment of such relationships would involve the use of systemwide approaches, which give rise to a number of structural consumer demand equations to represent interactions among the household budget shares for urban and interurban travel by alternative modes.

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